Preliminary Agenda…

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GROUNDWATER PROTECTION COUNCIL
OKLAHOMA CITY | SEPT. 27-30, 2015
ANNUAL FORUM

INTERSTATE Oil & Gas COMPACT COMMISSION

The 2015 ***Ground Water Protection Council*** *Annual Forum will Co-locate in Downtown Oklahoma City, OK with the* ***National Rural Water Association*** *and the* ***Interstate Oil and Gas Compact Commission****.*

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and Abstracts…

Preliminary Agenda: Version (08/31/15) –*Times and sessions subject to change…*

Sunday Sept. 27th	
12:30 5:00	**Cox Convention Center Ground Level Lobby** Registration
1:00 5:00	**Room 4** GWPC Board of Directors Meeting
6:00 8:00	GWPC & IOGCC Welcome Reception Vast Event Center - Atop the Devon Tower OKC 2015 Where Water & Energy Mix!

Monday Sept. 28th				
7:00	Registration and **GWPC Morning Reception** -- **Cox Convention Center Ground Level Lobby**			
8:30 10:30	**Room 5** **Professional Development Training** Ground Water Research & Education Foundation Spotlight series **Addressing the Challenges of Environmental Risk Communication** Instructor: **Dr. Bill Rish**, Hull Risk Analysis Center Environmental risk issues are increasingly raised to support polarized views, sometimes masking more relevant issues. Technical assessments of risk and public perceptions of risk often do not match. This workshop suggests how to improve risk communication by understanding the language of risk, factors that affect risk perception and risk acceptance, and using more effective and interactive approaches to dialogue about hazards and risks. This can ease public anxiety, build trust, and support properly informed decisions. Topics include: • The Language of Risk: How Risk Information is Developed and Described • Psychology and Social Aspects of Risk Perception and Risk Acceptance • Improving Practices in Environmental Risk Communication			**Room 4** **Water & Energy: Induced Seismicity by Underground Injection** Moderator: **Rex Buchanan** KSGS Abstract 20: Modeling of Pressure Propagation from Saltwater Disposal Wells Completed in the Arbuckle Group, northern Oklahoma **Kyle E. Murray**, Oklahoma Geological Survey Abstract 40: Understanding, Quantifying and Managing Risk from Injection-Related Earthquakes: A Case Study from Oklahoma **Rall Walsh**, Stanford University Abstract 3: Seismicity Issues – When the Potential for Liability meets the Promise of Data Sharing **Kate Konschnik**, Harvard Law Abstract 56: Investigating Injection-Induced Seismicity through Reservoir Modeling and Simulation of the Arbuckle Saline Aquifer, South-Central Kansas - **Tandis S. Bidgoli**, Kansas Geological Survey
9:45	**Exhibit Hall Grand Opening**			
10:50 Noon	**Room 12** **Hydraulic Fracturing and Your Community** Moderator: **John Satterfield**, Williams Co. Abstract 52: Water Cycle and Oil & Natural Gas Production - **Thom Kerr**, Thom Kerr, LLC Abstract 6: The Oklahoma Water Conundrum - **Steven Tipton**, ALL Consulting	**Room 2** **Water Quality: Dealing with Nutrients in Groundwater** Moderator: **Mike Baker**, OH EPA Abstract 9: Nutrient Reduction by Use of Deep Well Injection, Virginia Key, Miami-Dade CO, FL **Virginia Walsh**, Miami-Dade Water and Sewer Department, and **Edward Rectenwald**, MWH Americas, Inc. Abstract 46: Nutrients in Groundwater, and Public Water Supply Protection - **Joseph J. Lee,** Ground Water Protection Council Abstract 53: Assessing Nutrients in Principal Aquifers of the United States: An Overview - **Sandra M. Eberts**, USGS	**Room 3** **Water Availability and Sustainability:** Moderator: **Jamie Crawford**, Pickering Firm Abstract 19: A New Day for Alabama Groundwater Sustainability and Management: Science, Data Management, and Political Will, **Marlon Cook**, Geological Survey of Alabama Abstract 31: How Leadership Changes Affect Sustainability Measures of Public Water Systems **Lauren Behel**, Mississippi State University Extension	**Room 4** **Water & Energy: Induced Seismicity by Underground Injection** (cont.) Moderator: **Rex Buchanan** KSGS Communicating Induced Seismicity by Injection to the Public. (TBA)
Noon 1:30	**Lunch on Your Own**			

Ground Water Research & Education Foundation Spotlight series

Select sessions are part of the Spotlight Series…
…the technology transfer initiative of the
Ground Water Research & Education Foundation

GROUNDWATER RESEARCH & EDUCATION FOUNDATION

Monday Sept. 28th	
1:30 4:30	1:30-4:30 **Joint GWPC & IOGCC Session** **Ballroom D-E Cox Convention Center Second Level Lobby** **OKC 2015: Where Water & Energy Mix** **Mike Smith**, Executive Director, IOGCC & **Mike Paque**, Executive Director, GWPC • Oklahoma City Mayor – **Mick Cornett** • Utah Governor **Gary Herbert** • Oklahoma Governor **Mary Fallin** **Water & Energy Panel** Moderator **Mike Teague,** Oklahoma Secretary of Energy and the Environment (IOGCC Official Representative) • **Peter Grevatt**, Director Office of Ground Water and Drinking Water, U.S. Environmental Protection Agency • **Paula Gant,** Deputy Secretary for Fossil Energy, U.S. Department of Energy (invited) **GWPC/IOGCC State's First Initiatives** Moderator **- Larry Bengal**, Director, Arkansas Oil & Gas Commission • FracFocus – **Mike Paque**, Executive Director, GWPC • Inspector Training – **Gerry Baker**, Associate Director, IOGCC • Induced Seismicity Primer – **Rick Simmers**, Chief, Ohio DNR-Division of Mineral Resources Management
5:30 7:00	**IOGCC 80th Anniversary Reception** (All GWPC and IOGCC registrants welcome) Skirvin Hotel 14th Floor Ballroom, 1 Park Avenue, OKC (2 block from Convention Center)

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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Tuesday September 29th				
7:00	**GWPC Morning Reception** **Cox Convention Center Ground Level Lobby**			
8:00 9:30	**Room 12** **Drinking Water Providers Coordinating with the Oil & Gas Industry** Moderator: **John Satterfield**, Williams Co. Abstract 14: Hydraulic Fracturing Workshop Summary and Work Products - **Chi Ho Sham**, The Cadmus Group, Inc. Abstract 13: Colorado Water Watch - **Ken Carlson**, Colorado State University Abstract 60: The Oil & Natural Gas Industry Working to Enhance Water Management Technologies -**Jill E. Cooper**, Anadarko Petroleum Corporation	**Room 2** **Water Quality: Groundwater Protection** Moderator: **Marty Link**, NE DEQ Abstract 8: Potential Health and Environmental Impacts of Engineered Nanomaterials to Groundwater Resources, **Gregory P. Nichols**, ORAU Abstract 16: Protecting Groundwater in the Powder River Basin, Wyoming: Using Geophysical Logs to Map Confining Units and Ensure Surface Casing Isolation - **Carly Sowecke**, Chesapeake Energy Abstract 21: Quantifying the Potential Impact of Oil and Saltwater Spills to Oklahoma's Water Resources, **Glenn Brown** and Nelly Ruiz, Oklahoma State University Abstract 11: Overview and Implementation of Groundwater Sampling Rules in the State of Colorado, **Arthur Koepsell**, CO OGCC	**Room 3** **Water Availability: Deep Groundwater & Aquifer Management** Moderator: **Kevin Frederick**, WY DEQ Abstract 38: Hydrogeology, Distribution, and Volume of Saline Groundwater in the Southern Midcontinent and Adjacent Areas of the US – **William Andrews**, USGS Abstract 7: Uncertainty of groundwater movement in the brackish-water zone of the Edwards aquifer during drought conditions - **Linzy K. Brakefield**, USGS Abstract 15: Utilizing Petrophysical Log Data to Map the Pennsylvanian Stratigraphy and the Depth to Base of Treatable Groundwater in a Complex Fluvial System - **Laura Erichsen**, Chesapeake Energy	**Room 4** **Water & Energy: Unconventional Oil & Gas** Moderator: **Debby Yost**, Chesapeake Energy Abstract 18: Temporal Changes in Methane Concentrations in Shallow Groundwater, Appalachian Basin, Northeast Pennsylvania - **Mark Becker**, Chesapeake Energy Abstract 17: Methane occurrence and water-quality characteristics found in groundwater of the Appalachian Basin, **Bert Smith**, Chesapeake Energy Corporation Abstract 51: Marcellus Shale Coalition, Dissolved Methane Method Study - **Rock J. Vitale,** Environmental Standards, Inc. and **Debby Yost**, Chesapeake Energy Abstract 4: In situ methane detection: A new beacon for identifying contamination events and monitoring groundwater quality in real-time - **Zacariah L. Hildenbrand**, Inform Environmental
Break				
9:45 12:00	**Room 12** **Abandoned Oil and Gas Well Sites** Moderator: **Cathy Foerster**, AK O&GCC Abstract 48: Kentucky Abandoned and Orphan Well Plugging Program – **Kim Collings**, Kentucky Division of Oil & Gas Abstract 43: Arkansas Abandoned and Orphan Well Plugging Program **Gary Looney**, Arkansas Oil & Gas Com. Abstract 47: Kansas Abandoned and Orphan Well Plugging Program - **Patrick Shields**, Kansas Corporation Com. **Analyzing Water & Chemical Use Data: Hydraulic Fracturing Chemical Info.** Abstract 25: Water Use by Sector: An Analysis of FracFocus and USGS Water Use Data – **Mike Nickolaus**, GWPC Abstract: Quantities of Water and Proppant Associated with the Development of Continuous Reservoirs: Regional Scale Assessment Methodology, and Relevant Data from the Williston and Denver Basins - **Seth S. Haines**, USGS Central Energy Resources Science Center	**Room 2** **Water Quality: Source Water Protection for Domestic Wells** Moderator: **Evan Kane**, NC DENR-DWR Abstract 32: A Best Practices Manual for Outreach & Education to Private Well Owners **Steve Wilson**- State Water Survey, U. of Illinois Abstract 10: Environmental and Demographic Factors Affecting Domestic Well Usage in OK - **James W. Weaver**, USEPA Abstract 55: A National Program For Outreach & Education To Private Well Owners **Steve Wilson**- State Water Survey, University of Illinois Abstract 39: **North Carolina's Private Water Well Construction Standards** -North Carolina's Private Drinking Water Well Program – **Wilson Mize**, NC DHHS-DPH -Local Health Department Challenges and Successes in the Private Drinking Water Well Program – **Wilson Mize**, NC DHHS-DPH	**Room 3** **Water Availability: Groundwater Management & Planning** Moderator: **Kevin Frederick**, WY DEQ Abstract 23: Groundwater Management Decisions – Good Data leads to Good Decisions**, Derek Smithee**, OK Water Resources Board Abstract 26: Is Texas the Next Global Leader in Energy-Water Planning? Clean Technology and Data Hold the Answer **- Kate Zerrenner**, Environmental Defense Fund Abstract 27: Aquifer Recovery in South Arkansas and North Louisiana through Public Policy, Science, Monitoring and Partnerships - **Patrick J. Higgins,** Burns & McDonnell Engineering Abstract 29: ASR Status in the United States, **Fred Bloetscher**, FL Atlantic U.	**Room 4** **Water & Energy: Unconventional Oil & Gas** Moderator: **Debby Yost**, Chesapeake Energy Abstract 5: Investigation of Occurrences of tert-butyl alcohol in Raton Basin Groundwater - **Peter Gintautas**, Colorado Oil and Gas Conservation Commission Abstract 28: Stream Monitoring for Evaluating Groundwater Methane Associated with Shale-Gas Development - **Victor Heilweil**, USGS Abstract 33: Spill Response in Ohio: Practical Guidance for Operators of Horizontal Oil and Gas Wells **- Kris Andersen**, ALL Consulting Abstract 42: Health Risks from Drinking Water Impacted by a Flowback Water Spill in the Marcellus Shale Region - **William Rish**, Ph.D.,Hull Risk Analysis Center (HullRAC) Abstract 12: Innovative Tools to Optimize Fluids Management in the Shale Gas Industry **Ken Carlson,** & **Ashwin Dhanasekar**, Department of Civil & Environmental Engineering, Colorado State University

Tuesday September 29th				
	Room 12 **Analyzing FracFocus Data: Hydraulic Fracturing Chemical Information** (cont.) Moderator: **Cathy Foerster**, AK O&GCC Abstract 24: Hydraulic Fracturing Chemicals Reporting: Analysis of FracFocus 1.0 and 2.0 - **Kate Konschnik**, Harvard Law Abstract 36: Analysis of Hydraulic Fracturing Fluid Data from the FracFocus Chemical Disclosure Registry 1.0 - **Jeanne Briskin**, USEPA	**Room 2** **Water Quality: Source Water Protection for Domestic Wells** (cont.) Moderator: **Evan Kane**, NC DENR-DWR -Collaboration between Public Health and Environmental Agencies – **Wilson Mize**, NC DHHS-DPH, NC DENR-DWR -Data Management Improvements to Support Private Well Programs- **Evan Kane**, NC DENR-DWR	**Room 3** **Water Availability: Groundwater Management & Planning** (cont.) Moderator: **Kevin Frederick**, WY DEQ Abstract 59: Stakeholder Engagement and Development of Water Management Strategies **- Andra Wilcox** – Environmentally Friendly Drilling Systems	**Room 4** **Water & Energy: Unconventional Oil & Gas** (cont.) Moderator: **Debby Yost**, Chesapeake Abstract 30: Shale Energy Produced Fluids Management and UIC Well Disposal Trends - **David Yoxtheimer**, Penn State University Abstract 35: How Things Have Changed: Class II Disposal Wells and Unconventional O&G Development - **William Hochheiser**, ALL Consulting
Noon 1:30	**Lunch on Your Own**			
1:30 2:30	**Room 12** **Competing Demands for Water Supply** Moderator: **Dale Kohler**, TX CEQ Abstract 2: America's Dependence on Ground-water: Market Segment Trends in a Changing Marketplace - **Kevin McCray** NGWA Abstract 54: Making Use of Groundwater as Part of an Alternative Water Supply Strategy for Adaptation to Climate Change – **Jamie Crawford**, Pickering Firm Abstract 1: Diminishing Water Re-sources: The Need for Inter-disciplinary Holistic Approaches to Groundwater Development and Management **- James W. Roberts**, Pro. Engineering Cons.	**Room 2** **Oil & Gas Environmental Information** Moderator: **Mike Paque**, GWPC Abstract 49: **Meg Coleman**, USDOE and **Paul Jehn**, GWPC • GWPC and the National Oil & Gas Gateway • WaterTracker: Tracking the use and disposal of water associated with oil and gas production • RBDMS Environmental Application for all water monitoring programs	**Room 3** **Class V UIC Roundtable** (open to all with interest in Class V UIC regulatory issues)	**Room 4** **Water & Energy: Oil & Gas Produced Water Management** Moderator: **Mike Nickolaus**, GWPC Abstract 22: Innovative Process to Recycle Shale Gas Produced Water Utilizing By-Product Recovery Eliminating Disposal via Deep Well Injection**, Tom Lewis**, Lewis Environmental Services Abstract 41: Produced Water Volumes and Management Practices - **John Veil**, Veil Environmental, LLC.
Break				
2:45 3:50	**Room 12** **Source Water Protection** Moderator: EPA Source Water Session: Source Water Tools and Program Updates – SWP Programs Overview – DWMaps – Source Water Collaborative: New and Updated Toolkits – CWA/SDWA Integration Toolkit (this session ends at 4:45)	**Room 2** **Groundwater Monitoring** Moderator: **Kevin Frederick**, WY DEQ Abstract 37: Development and Implementation of the National Ground-Water Monitoring Network **Daryll Pope**, USGS Abstract: NAWQA groundwater monitoring effort, where state data could fit in. – **Sandra Eberts**, USGS	**Room 3** **Hydraulic Fracturing and Water** Moderator: Abstract 61: Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources in the United States –**Jeff Frithsen**, USEPA Abstract 45: Water Use for High Volume Hydraulic Fracturing in Oklahoma, **Robert W. Puls**, Robert Puls Environmental Consulting, LLC Abstract 44: High Volume Hydraulic Fracturing and Protection of Public Water Supply Sources - **Joseph J. Lee**, GWPC	**Room 4** **Class II UIC &** **Oil & Gas Roundtable** **(State Regulators Only)**
4:00 6:00	**Room 12** (this session ends at 4:45) **EPA Source Water Protection** (cont.)	4:00-6:00 **State / Federal Forum** (State and Federal agency employees only, please) **Room 3** • 4:00-5:00 – USGS and USDOE Discussion • 5:00-6:00 – USEPA Discussion		

Wednesday September 30th				
7:00	**GWPC Registration and Morning Reception** Cox Convention Center Ground Level Lobby			
8:00 12:00	**Room 12** (this session begins at 9:45) **Innovations in Water Reuse:** Moderator: **Shellie Chard-McClary**, OK DEQ 9:45-11:00 Water Reuse Establishing a New Regulatory Environment: EPA's Perspective on Water Reuse – **Peter Grevatt**, EPA Director, Office of Groundwater and Drinking Water, and **Bill Honker**, EPA Director Office of Water Region 6 11:00-12:00 State Approaches and Innovative Water Reuse Solutions **Patty Thompson**, Oklahoma DEQ; **Kim Wilson**, Texas CEQ; and **Saba Tahmassebi**, Oklahoma DEQ	8:30 – 10:40 **Room 2** (this session begins at 8:30) **Class I UIC Technical Session:** Moderator: **Lindsay Taliaferro**, OH EPA Abstract 58: Geologic Feasibility of Class I Injection Wells in the Deep Illinois Basin - **Monte Markley** and **Stephanie Hill** – SCS Aquaterra Abstract 57: Water Quality Treatment Considerations for Non-Hazardous Disposal Wells Injecting Under Pressure - **Chad Milligan** and **Nicole Franken** – SCS Aquaterra Abstract: Challenges to Class I well Permitting and Operations **– Bob Van Voorhees**, Underground Injection Technology Council 11:00-12:00 **State Regulators Only: Class I UIC Roundtable** TBA	**Room 5** (this session begins at 9:45) Ground Water Research & Education Foundation Spotlight series **Groundwater Training** Instructor: **Mike Wireman** – Hydrogeologist, USEPA (retired) **Basic Principles of Groundwater Occurrence and Flow** Key concepts of hydrogeology, groundwater flow, groundwater quality, aquifer hydraulic properties, surface water -groundwater interaction	8:00 – 12:00 **Room 4** Ground Water Research & Education Foundation Spotlight series **Class II Disposal Well Best Management Practices Workshop** Instructor: **Dan Arthur**, ALL Consulting Abstract 34: Class II saltwater disposal wells are an essential component of unconventional oil and gas development. Public attention has been focused on hydraulic fracturing, but now some of that attention has focused on Class II injection wells, as issues such as ground water protection, potential injection-related induced seismicity, waste water radioactivity, and truck traffic have become more publicized. This course will focus on understanding the key aspects of Class II injection well disposal, and address some of the challenges.
Noon 1:20	**Grand Ballroom Cox Convention Center Second Level Lobby** Oklahoma City, 2015: Where Water & Energy Mix Joint NRWA, IOGCC, GWPC Luncheon **Leslie Savage**, Deputy Director, Oil & Gas, Railroad Commission of Texas (GWPC President) **Mary Fallin**, Oklahoma Governor, IOGCC OKC 2015 Where Water & Energy Mix!			
Break				
1:30 3:00	**Room 12** **Innovations in Water Reuse:** (cont.) Moderator: **Shellie Chard-McClary**, OK DEQ Water Reuse in Action • **Marsha Slaughter**, Oklahoma City Water Utility Trust • Abstract 50: Municipal Wastewater Reuse in Oklahoma - **Robert W. Puls,** Robert Puls Environmental Consulting, LLC • **Ray Longoria**, Freese and Nickols	**Room 2** **State Regulators Only: Class III UIC Roundtable** TBA	**Room 5** **Groundwater Training** (cont.) Instructor: **Mike Wireman** – Hydrogeologist, USEPA (retired) **Transport and Fate of Contaminants in Groundwater** Key concepts in physical, chemical, biological processes that control transport, chemistry and distribution of contaminants in the subsurface	**Room 4** **FracFocus 3.0 Training** Moderators: **Mike Nickolaus** & **T.J. Groves** GWPC • Introduction and history of FracFocus Transition from FF 2.0 to FF 3.0 • FracFocus 3.0 Features • Preparing and Submitting FroacFocus Disclosure • FracFocus 3.0 XML Schema • Q&A

Abstract 1

Diminishing Water Resources: The Need for Inter-disciplinary Holistic Approaches to Groundwater Development and Management

James W. Roberts, Professional Engineering Consultants

Groundwater is the largest source of unfrozen fresh water on earth and is a resource that is in transition. That is to say that the taking and use of groundwater have resulted in unprecedented changes in total storage volumes to the point that groundwater basins across the globe are, in many cases, being depleted faster than they can be recharged. This phenomena has been driven by population growth, scientific and technological progress, economic development, the need for food and climate extremes.

The current trend in groundwater use is unsustainable. Because storage, movement and quality of groundwater, as well as gaining access to existing supplies are linked to the geologic environment, logic dictates that geoscientists play a significant integral role in the formulation of strategy related its development and management.
Jim Roberts is a Groundwater Geologist with Professional Engineering Consultants, P.A. (PEC) in Oklahoma City, OK. He graduated from the University of Oklahoma with a BS degree in Geology and completed post graduate hydrology studies at Oklahoma State University. He is a Professional Associate with PEC, a licensed geologist in Kansas, and has 28 years of professional geological experience working in the groundwater, environmental and petroleum industries.

Mr. Roberts' professional interests are focused on groundwater geoscience and the utilization of petrophysical logs, hydrology and groundwater chemistry datasets to identify and characterize aquifer sweet spots at local and regional scales. Current and past work includes management and supervisory oversight of projects to address issues related to source identification, supply, water quality and use. Mr. Roberts is recognized as a technical area expert in the characterization and delineation of geologic, hydrologic and geochemical conditions in bedrock and alluvial aquifers.
Mr. Roberts adopted and perfected an empirical method for establishing the relationship between groundwater chemical data and open-hole resistivity logs to quantify and delineate regional and local scale variations in groundwater chemistry in Oklahoma's Permian bedrock aquifers. The technique was developed in cooperation with the U.S. Department of Energy, the Oklahoma Corporation Commission and the Ground Water Protection Council Research Foundation to aid in the establishment of appropriate surface casing depth-setting requirements for the petroleum industry in Oklahoma.

Mr. Roberts has broad experience with the application and use of various surface and subsurface investigation and characterization techniques, groundwater chemistry, forensic geochemistry, groundwater law, regulatory permitting, expert witness testimony and public speaking. Over the years he has consulted for a variety of groundwater stakeholders including municipalities, rural water districts, engineering firms, law firms, drilling contractors, nonprofit organizations, ranching operations, state and federal government, petroleum companies, oil and gas service companies, power companies and an investment banking firm.

Abstract 2

America's Dependence on Groundwater: Market Segment Trends in a Changing Marketplace

Kevin McCray, National Ground Water Association

The United States extracts 76 billion gallons per day of fresh groundwater -- the water filling the cracks and other openings in beds of rock and sand -- for public supply, private supply, irrigation, livestock, manufacturing, mining, thermoelectric power, and other purposes.

Irrigation is a major reason for the abundance of fresh produce and grains that benefit man. Irrigation accounts for the largest use of groundwater in the U.S., about 65 percent of all that is pumped from the subsurface each day. In 1900, the U.S. used only 2.2 billion gallons (bgd) of groundwater daily for agricultural irrigation from 17,000 wells. Today, some 49.5 bgd of groundwater is used daily for U.S. irrigation from a growing number of nearly 476,000 wells. Despite this, irrigation groundwater extraction volumes have decreased nearly 15 percent from 2000 levels.

However, throughout many of the western states relying heavily upon groundwater for irrigation, there are growing competing demands for the water to develop energy resources, sustain ecological systems, as well as to supply urban population centers.
This presentation examines the national trends in groundwater use, as well as some of the implications for groundwater use from shifting populations and competing demands for water. A new database compiled by the National Ground Water Association will be presented.

Abstract 3

Seismicity Issues – When the Potential for Liability meets the Promise of Data Sharing

Kate Konschnik, Harvard Law

Liability concerns about induced seismicity have grown recently, in the wake of press reports and an Oklahoma Supreme Court ruling. Going forward, earthquakes will be attributed to oil and gas operations, although causation and in some states, evidence of deviation from industry practice or a state regulation, may pose significant hurdles to recovery. This presentation will offer a basic discussion of common law theories of liability and the evidence that different states require to award damages.

More data is required to understand and minimize the possibility of induced seismicity in particular areas. In addition, existing data sets should be shared across sectors. Industry, state geological surveys, and the U.S. Geological Survey monitor seismicity in different geographic areas. Other private and public entities track activities that may correlate to the frequency or distribution of tremors. If they were able to consult data from all of these entities, States could supplement limited monitoring resources and learn more about background seismicity levels and potential drivers of induced seismicity. Moreover, public data sharing could improve public confidence in state oversight functions, and encourage people to share information that supplements institutional data-gathering activities. However, liability fears pose an obstacle to data sharing with regulators and the public.

The presentation will discuss mechanisms to promote data sharing with liability concerns in mind. The presentation will also explore liability funds as a way to address some potential claims related to induced seismicity. A few states have established funds to address this risk, whether potentially triggered by oil and gas activity, wastewater injection, geothermal development, or carbon capture and sequestration (CCS) projects. Some funds merely provide a revenue source for state monitoring; others cover damages that may be caused by induced seismicity. These types of funds can lower the burden of proof and expedite claims processing for a person seeking compensation, while reducing the liability profile for potentially responsible parties. The presentation will offer examples of existing state seismicity funds, funds established to address other risks (e.g., the Fisherman's Contingency Fund, or state funds to address leaking underground storage tanks), and proposals for new types of liability funds.

Kate Konschnik is the founding Director of Harvard Law School's Environmental Policy Initiative (EPI), a policy shop providing real world legal analysis of hot topics in energy and climate. EPI has worked with and presented research to state and national organizations including the National Research Council, the National Governors' Association, the Midwestern Power Sector Collaborative, and the United States Secretary of Energy's Advisory Board.

Previously, Kate served as Chief Environmental Counsel to a U.S. Senator and directed his subcommittee on the Senate Environment and Public Works Committee. From 2002 to 2009, Kate also served as a trial attorney at the U.S. Department of Justice.

Abstract 4

In situ Methane Detection: A New Beacon for Identifying Contamination Events and Monitoring Groundwater Quality in Real-time

Zacariah L. Hildenbrand[1,2], Josh Taylor[1], Nick Nickerson[3] and Dan Plant[3]

1) Inform Environmental, LLC; 2) University of Texas at Arlington; 3) Forerunner Research, Inc.

Dr. Zacariah L. Hildenbrand received his bachelors and Ph.D. degrees from the University of Texas at El Paso and completed a post-doctoral research fellowship at the University of Texas Southwestern Medical Center in Dallas. Dr. Hildenbrand is the founder of Inform Environmental, LLC, an environmental consulting firm tailored to address the environmental concerns associated with oil and gas extraction. He also sits on the scientific advisory board of the Collaborative Laboratories for Environmental Analysis and Remediation at the University of Texas at Arlington, where he has coordinated research studies evaluating groundwater quality throughout the Barnett, Cline and Eagle Ford regions of Texas. Dr. Hildenbrand is determined to provide a further understanding of unconventional drilling and to develop solutions and new technologies for groundwater remediation, the recycling of fluid waste products, and the rapid characterization of groundwater quality.

The extraction of oil and natural gas from shale reserves has brought significant concerns over unconventional drilling and the degradation of groundwater quality. Of particular concern is whether rogue methane and is leaching into groundwater through faulty well casings or through interconnectivity between the extraction zone and the overlying aquifer. Previous reconnaissance efforts analyzing dissolved gases across the major shale plays of Texas have revealed methane levels well in exceedance of the 28 mg/L threshold; above which water is flammable and the Department of the Interior and the Office of Surface Mining advises well owners to contact their local health authorities. The current protocols for the testing and monitoring of dissolved methane are extremely expensive and finicky, requiring absolute precision during sample collection to yield reliable data. Here we present novel detection hardware for the quantification of dissolved methane *in situ* with remote reporting capabilities in real-time. The sensitivity, durability, and accuracy of this technology provide industry entities, municipal well operators and concerned citizens with the opportunity of executing a high-resolution monitoring program for a small fraction of the historical cost.

Abstract 5

Investigation of Occurrences of *tert*-butyl alcohol in Raton Basin Groundwater

Peter Gintautas Colorado Oil and Gas Conservation Commission

Peter Gintautas is an environmental protection specialist with the COGCC. Peter has more than 30 years of experience in geology and geochemistry as well as a Ph.D. in geochemistry.

COGCC investigated the occurrence of *tert*-butyl alcohol (TBA) in groundwater from aquifers in the Raton Basin. The presence of TBA in Raton Basin groundwaters was documented in samples collected in parallel with a national study of hydraulic fracturing. The purpose of the COGCC investigation was to determine spatial occurrence and also to identify potential sources of TBA and to evaluate potential fate and transport mechanisms of TBA from any sources identified in the investigation.

TBA is a branched four carbon alcohol used in many industrial processes and is found in consumer products and has been used as a gasoline additive. It is also produced in groundwater, under certain conditions, as a metabolite of the gasoline fuel oxygenate additive MTBE. It has been detected in alcoholic beverages, which may indicate that TBA is naturally occurring, although its presence in shallow groundwater as a naturally occurring organic compound is not documented in literature. In terms of TBA occurrences related to oil and gas activity, when the compound *tert*-butyl hydroperoxide is used as a gel breaker in frac fluids, TBA can be produced through a linked oxidation/reduction process. TBA may also be produced through in situ microbial degradation of naturally occurring isobutane. TBA was present in groundwater samples collected from 24% of the domestic water wells sampled and was also present in produced water from 22% of the CBM wells sampled. This investigation indicates there is no data linking oil and gas activity as the source of TBA in water wells in the Raton Basin. Anthropogenic sources of TBA in groundwater may result from immersion of products commonly used in well construction such as pipe sealant or from compressed air used during air percussion drilling of wells. Natural occurrences of TBA in groundwater may result from the oxidation of isobutane by methanotrophic bacteria.

Abstract 6

The Oklahoma Water Conundrum

Steven Tipton, Dan Arthur, and David Alleman - ALL Consulting

D. Steven Tipton, P.E., Senior Engineer; BS – Chemical and Petroleum Refining Engineering from Colorado School of Mines 1967; MS – Petroleum Engineering from the University of Tulsa 1974; Registered Professional Engineer in Texas and Oklahoma

Mr. Tipton is a registered professional petroleum engineer specializing in water issues. He has more than 47 years of experience, primarily in drilling, completion, and production operations throughout the U.S., Canada, Trinidad and Yemen. He spent the last 5 years before his retirement from Newfield as water manager for the company's completion operations in the Mid-Continent. He is currently employed by ALL Consulting in Tulsa, Oklahoma.

Water is essential to the success of any oil and gas operation, especially during the completion of horizontal shale or tight sand wells. However, Oklahoma is in the midst of a long term drought so there is enormous pressure from the public to reduce freshwater use, and to use water sources other than fresh water. Further, as activity in the unconventional reservoirs has increased, there has been a concurrent increase in seismic activity in the state. Scientists have linked this seismic activity to the increasing volume of produced water being disposed in Arbuckle SWD wells.

To address these concerns, operators are exploring ways to re-use or recycle produced water. Operators are also exploring the use of alternative water sources such as saline aquifers or other non-potable sources. In addition, operators are exploring ways to reduce the volume of water injected for disposal. These new approaches to water management have led to a number of challenges regarding planning, technology, and regulations. This presentation will address some of these challenges, and provide insights into how these challenges might be met.

Abstract 7

Uncertainty of Groundwater Movement in the Brackish-water Zone of the Edwards Aquifer During Drought Conditions

Linzy K. Brakefield and Jeremy T. White U.S. Geological Survey Texas Water Science Center

Linzy K. Brakefield is a civil engineer/hydrologist with the U.S. Geological Survey Texas Water Science Center in Austin, TX. Her research focuses on numerical modeling of groundwater flow, contaminant transport, and density-dependent flow, as well as uncertainty quantification in numerical models. Jeremy T. White is a hydrologist with the U.S. Geological Survey Texas Water Science Center in Austin, TX. His research focuses on numerical simulation of groundwater and surface water systems, as well as parameter estimation and uncertainty quantification in geophysical and hydrologic models.

Water from the Edwards aquifer is relied on by approximately 2 million residents, industrial, commercial and agricultural entities, as well as threatened and endangered species in south-central Texas. Numerous groundwater-flow models have been developed to simulate regional groundwater-flow directions and water budgets for the San Antonio and Barton Springs segments of the freshwater zone of the Edwards aquifer. Although the Edwards aquifer extends downdip past the freshwater zone, the primary focus of research has been on the freshwater extent. Compared to the freshwater zone, scientific knowledge of the brackish-water transition zone is scant. An improved understanding of potential groundwater movement in the brackish-water transition zone will help refine the understanding of the conditions under which the freshwater zone might be vulnerable to migration of brackish water.

The potential for migration of lower-quality brackish water into freshwater is greatest during drought conditions when freshwater heads are low and demand for potable water remains high. To evaluate the potential for brackish water to migrate updip, an existing MODFLOW model was converted to a density-dependent SEAWAT model for the San Antonio segment of the Edwards aquifer. The model was history-matched to observations of water level, spring flow and total dissolved solids (TDS) concentration for the period of 1999 to 2009. Linear-based uncertainty analysis was used to estimate the upper 95th percentile credible limit of TDS concentration change expected at several production wells near the brackish-water transition zone during the 1950s period-of-record drought. The prior 95th percentile credible limit (prior to history-matching) exceeds the secondary drinking water standard (SDWS) for TDS concentration, demonstrating the uncertainty that exists in the specification of expert knowledge. However, after parameters are conditioned to observations through history-matching, the posterior 95th percentile credible limit is below the SDWS, demonstrating the importance of the information contained in the historical observations.

Abstract 8

Potential Health and Environmental Impacts of Engineered Nanomaterials to Groundwater Resources

Gregory P. Nichols, ORAU

Mr. Nichols is currently the Program Manager for Nanotechnology Studies at ORAU, located in Oak Ridge, Tennessee. He provides subject matter expertise on nanotechnology and related health, environmental, and social policy. He has published on a variety of topics related to public health and is the co-author of a book chapter on the use of epidemiology in risk assessment. He has been an invited speaker on many topics including nanotechnology. He has a master's degree in public health from the University of Tennessee and also holds the Certified in Public Health credential.

Despite the ubiquitous use of engineered nanomaterials, there is a paucity of research regarding many aspects of their use. Little is known about the long-term human health and environmental impacts of nanotechnology. Concerns have been raised regarding the lack of knowledge about the life-cycle of engineered nanomaterials. Further research in this area is still needed, but it is possible that these emerging contaminants could enter surface and groundwater resources through a variety of pathways.

Evidence shows that engineered nanomaterials can be present in wastewater from household activities, such as washing clothes that contain engineered nanomaterials. They could also be contained in the effluent of facilities that use or manufacture engineered nanomaterials, especially in the electronics industry. Certain types of nanomaterials are used to assist in environmental remediation, but their ultimate endpoint is unknown. Products that contain engineered nanomaterials have the potential to breakdown over time and nanoparticles could be introduced into the environment during waste management activities. Limited data are available regarding ecological toxicity and exposure potential of nanomaterials since no efficient methods to determine fate and transport of engineered nanomaterials are currently available, nor are there any reliable methods to characterize the presence of engineered nanomaterials in soil or water. Even with the widespread use of nanomaterials, there continues to be a lack of regulation, partly because there are no standardized testing procedures. Lack of scientific evidence limits the ability to set standards and regulations regarding safe exposure limits for engineered nanomaterials. More information is needed to characterize industrial activities that use engineered nanomaterials to ensure that better methods can be developed to safeguard public health, protect water resources, and increase industry awareness. However, regulators should be aware of the emergence of engineered nanomaterials, how they might affect groundwater resources, and possible methods to mitigate exposure to the public.

Abstract 9

Nutrients Reduction by use of Deep Well Injection, Virginia Key, Miami-Dade County, Florida

Virginia Walsh, Miami-Dade Water and Sewer Department and **Edward Rectenwald**, MWH Americas, Inc.

Virginia Walsh, P.G., Ph.D., Miami-Dade Water and Sewer Department: Dr. Walsh has over 18 years experience as a hydrogeologist in various hydrologic, geologic, and environmental investigations. She has been Chief of the Hydrogeology Section at MDWASD for over the past 7 years. Dr. Walsh received her Ph.D. in Geology from Florida International University in 2012. Dr. Walsh and her staff are responsible for all hydrogeologic investigations for MDWASD, and are involved in the design, operation and maintenance of water production wells and the deep injection well systems at MDWASD. She is also the Project Manager for the Aquifer Storage and Recovery cycle testing at MDWASD South and West wellfields.

Edward Rectenwald, P.G., MWH Americas, Inc.: Mr. Rectenwald is a Principal Hydrogeologist and Client Service Manager in south Florida with over 19 years of technical and management experience. His experience includes regional aquifer investigations, water use permitting, hydraulic modeling, design and testing of aquifer storage and recovery wells (ASR), injection wells, public and industrial supply reverse osmosis (RO) wells, irrigation wells, and monitor wells. Mr. Rectenwald has managed detailed geochemical investigations to better understand flow patterns of the Floridan Aquifer System using stable isotopes, carbon-14, and noble gases.

Miami-Dade Water and Sewer Department (MDWASD) operates the Central District Wastewater Treatment Plant (CDWWTP) on Virginia Key, Miami-Dade County, Florida. Average daily flows of 114 mgd of treated domestic wastewater are disposed of via ocean outfall at CDWWTP. Florida Statutes Chapter 403 Section 086(9)(b) require that the discharge of domestic wastewater through the ocean outfalls must meet advanced wastewater treatment (AWT) and management requirements no later than December 31, 2018. This requirement can be met by reducing the outfall baseline loadings of total nitrogen (TN) and total phosphorus (TP) which would be equivalent to that which would be achieved by the AWT requirements fully implemented beginning December 31, 2018, and continued through December 31, 2025.

Nitrogen ammonia concentrations in the centrate generated by the sludge dewatering process at CDWWTP range from 42 mg L^{-1} to 3260 mg L^{-1}, with an average of 873 mg L^{-1}, with an average 1.2 mgd of centrate flows. Preliminary calculations have indicated that 59.9 million pounds of TN can be diverted from the existing ocean outfall if the centrate is disposed of via deep injection wells (DIW) by June 2016. This represents 34% of the TN loading removal from the ocean outfall which will meet the 2025 AWT requirements once fully implemented.

MDWASD has started construction of a Class V Exploratory well to evaluate the hydrogeologic characteristics of the Boulder Zone located below the Underground Source of Drinking Water (USDW) in the Early Eocene age Oldsmar Formation of the Floridan Aquifer System (FAS) for the purpose of nutrient disposal. The Class V Exploratory well is permitted to drill to a depth of 10,000 feet below land surface in order to also investigate the hydrogeologic characteristics within Cretaceous age formations underlying the FAS as another option for disposal in south Florida.

Abstract 10

Environmental and Demographic Factors Affecting Domestic Well Usage in Oklahoma

James W. Weaver, Fran V. Kremer, USEPA

James W. Weaver is a research hydrologist with the U.S. EPA who works on subsurface contaminant transport, leaking underground storage tanks and their impacts on drinking water supplies. Fran V. Kremer is an environmental engineer with the U.S. EPA who works on preventing ground water contamination and treatment approaches.

Domestic wells supply drinking water to residents in rural, suburban and exurban areas. These wells are subject to contamination from various sources including hazard waste sites, leaking underground storage tanks, nitrate from agricultural activities, naturally-occurring contaminants like arsenic, and others. Neither the federal nor state governments require testing of private, domestic wells, so residents are at risk for consuming contaminated water. The location and density of domestic well use, and its location relative to contaminant sources is controlled by demographic and environmental factors. Baseline national data on domestic well use was last collected in 1990 by the U.S. Census Bureau. Since then, well logs reported to the Oklahoma provide the basis for updated well density estimates. Where areas can be identified that are entirely dependent on domestic wells, the estimates have been tested and found to be reasonable. The resulting patterns of domestic well density are primarily influenced by the locations of city limits, areal extents of public water systems, growth in population, and the presence of productive aquifers. In Oklahoma, the highest density of domestic wells is found in roughly a ring around Oklahoma City. Similar high density is not found around Tulsa, primarily due to less abundant aquifers and more abundant surface water. Our continuing work is focused on two areas. First, by separating data into categories based on the presence of major aquifers, public water supplies, and city limits we are attempting to develop regression formulas to estimate domestic well density. Second, we are developing an approximate metric for the median distance between domestic wells, based on their density, and the locations of leaking underground storage tank sites.

Abstract 11

Overview and Implementation of Groundwater Sampling Rules in the State of Colorado

Arthur Koepsell, Colorado Oil and Gas Conservation Commission

Mr. Koepsell is an Environmental Protection Specialist for the Colorado Oil and Gas Conservation Commission (COGCC). Mr. Koepsell manages the data collected under the COGCC groundwater sampling rules. Prior to working for the COGCC Mr. Koepsell worked as a consultant in both the environmental and water resources fields.

Mr. Koepsell will present an overview of the Colorado Oil and Gas Conservation Commission (COGCC) Rules 318A.f and 609 and describe how the collected data are managed electronically. Approximately 2,100 oil and gas wells are drilled in Colorado on an annual basis with majority of the wells being hydraulically fractured—this oil and gas activity led to a desire to obtain groundwater quality information before and after, and in close proximity to, drilling and completion activities. COGCC Rules 318A.f and 609 require baseline and post-completion sampling and these Groundwater Sampling Rules went into effect On May 1, 2013 with Colorado as the first state to impose such requirements. Rules 318A.f is applicable only in the Greater Wattenberg Area (GWA) northeast of Denver, Colorado; Rule 609 covers the entire state with the exception of the GWA.

The presentation will describe Rule requirements including required number of samples, required analytes, sample location selection, and sample timing. The presentation will detail COGCC's electronic administration of the rules using the COENV Database System and eFORM data management system. The COENV database system is used to manage the analytical data that has been collected under Rules 318A.f and 609 through use of an electronic data deliverable (EDD). Colorado's eFORM data management system is used to administer other information submitted to the COGCC relevant to Rules 318A.f and 609. The electronic management of data provides unprecedented public access to sample results throughout the state and allows COGCC to utilize the data in real time to evaluate trends and identify anomalies.

Abstract 12

Innovative Tools to Optimize Fluids Management in the Shale Gas Industry

Ken Carlson, Ashwin Dhanasekar, Department of Civil & Environmental Engineering, Colorado State University

Colorado, with its semi-arid environment, increasing development and flourishing agriculture, only helps in constraining the availability of its local water resources. The oil and gas industry's rapid development is only escalating the pressure on water and other natural resources. The surging water handling challenges are clearly having a profound impact on unconventional oil and gas operators. Managing fluids in shale plays is a dynamic challenge requiring the integration of multiple factors such as changing water chemistry, variable flow rates, regulations and public concerns. Hence, the need for a dynamic fluids management tool is indispensable. The Center for Energy Water Sustainability, housed under the Energy Institute, partnering with real world industry like Noble Energy and Halliburton is working on various projects to develop a comprehensive fluids management tool. Based on various case studies performed in the Wattenberg field of Colorado, algorithms are being developed for water use and production with respect to different characteristics such as type of fracturing fluid used, formation being tapped into and spatial variability. Produced and flowback water is also being analyzed by their water quality to assess the level of treatment it requires before being reused for fracing. Public concerns about safety and protection of the environmental during hydraulic fracturing of unconventional shale resources is not limited to water supply issues but also include surface and ground water quality concerns, air quality impacts, and community impacts such as noise, truck traffic and road damage. While this tool is focused on water, it also covers all relative impacts to consolidate integrated infrastructure modeling. In order to comply with current and future regulations, as well as economic viability, operators should optimize their water management strategies. A tool like this will help make operators' life considerably easier, while also ensuring they address public concerns to safeguard long-term resource development.

Ashwin Dhanasekar is a Research Associate at Colorado State University and a Senior Researcher for the Center for Energy Water Sustainability (CEWS). He has M.S in Environmental Engineering from Colorado State University and a B.S in Chemical Engineering from Anna University (India). He is currently working through the CEWS with operators and service companies to help manage their water more efficiently. His previous work include developing improved water

analytics for the Texas region working on different plays including the Permian & Barnett, which included analyzing produced water by geological formation and disposal wells utilization.

Ken Carlson is a Professor of Civil and Environmental Engineering at Colorado State University and also serves as Director of the Center for Energy and Water Sustainability within the CSU Energy Institute. Ken has over 25 years of experience in water and energy related issues and has a BS in chemical engineering from the University of Wisconsin, a MS in Civil Engineering from Colorado State University, and a PhD in Environmental Engineering from the University of Colorado Boulder. Ken has been directing efforts to optimize shale oil and gas water management through partnerships with E&P companies, service providers and government agencies.

Abstract 13

Colorado Water Watch

Ken Carlson, Ashwin Dhanasekar, Department of Civil & Environmental Engineering, Colorado State University

Oil and gas activity in northern Colorado has been a major concern for changes in water and air quality. Ideally the State should be able to monitor the potential impacts real-time and provide the public the assurance of safe air and water at all times. This is not practical since real-time monitoring of criteria pollutants (e.g. benzene in air, methane in water) is not feasible with current technology. Instead, Colorado State University is proposing to establish a regional monitoring network that would provide real-time measurement of air and water quality pollutant surrogates. The surrogate analyses chosen need to be practical to measure in a continuous, real-time manner and need to have proven to correlate with the presence of criteria pollutants from oil and gas activity. Heightened public concern regarding the safety of oil and gas development (particularly when accomplished with hydraulic fracturing) is partially related to a lack of easily understandable, current information regarding the presence of pollutants in air and water. Scientific reports describing studies that were done under conditions seemingly unrelated to one's daily life are prone to being misinterpreted and do not always contribute to an informed citizenry. It is the intention of this project to bridge this gap by involving social science faculty and students at CSU in the development of a web-based interface that will hopefully be an effective tool for providing information to the public regarding air and water quality related to oil and gas development. Since a real-time air and water quality-monitoring network aimed at oil and gas related impact is a large undertaking, the scope of the proposed project is limited to water quality. The three key elements of the project are installing sensors, establishing a telemetry system and developing a public web-based interface.

Ashwin Dhanasekar is a Research Associate at Colorado State University and a Senior Researcher for the Center for Energy Water Sustainability (CEWS). He has M.S in Environmental Engineering from Colorado State University and a B.S in Chemical Engineering from Anna University (India). He is currently working through the CEWS with operators and service companies to help manage their water more efficiently. His previous work include developing improved water analytics for the Texas region working on different plays including the Permian & Barnett, which included analyzing produced water by geological formation and disposal wells utilization.

Ken Carlson is a Professor of Civil and Environmental Engineering at Colorado State University and also serves as Director of the Center for Energy and Water Sustainability within the CSU Energy Institute. Ken has over 25 years of experience in water and energy related issues and has a BS in chemical engineering from the University of Wisconsin, a MS in Civil Engineering from Colorado State University, and a PhD in Environmental Engineering from the University of Colorado Boulder. Ken has been directing efforts to optimize shale oil and gas water management through partnerships with E&P companies, service providers and government agencies.

Abstract 14

2014 Hydraulic Fracturing Workshop Sponsored by Water Research Foundation, American Water Works Association, and Ground Water Protection Council: Workshop Summary and Work Products

Chi Ho Sham, Ph.D., Jonathan Koplos, Ph.D., and Erina Keefe, The Cadmus Group, Inc.

Dr. Chi Ho Sham, the Chief Scientist at Cadmus, has worked on underground injection control, source water protection, and natural resource management for the past three decades. Dr. Jonathan Koplos, a Principal at Cadmus, has more than 25 years of experience in environmental science and policy consulting that includes the evaluations of contaminant occurrence in drinking water and technical and policy issues related to geologic sequestration and hydraulic fracturing. Ms. Erina Keefe, an Analyst at Cadmus, holds a B.S. in Environmental Science and Public Health and has provided technical support to the U.S. Environmental Protection Agency on drinking water issues.

The United States has been and is experiencing a significant surge in oil and gas production, mainly driven by technological advancements (such as hydraulic fracturing and directional drilling) that were developed primarily for natural gas production from unconventional hydrocarbon reservoirs. The rapid and likely sustained expansion of domestic oil and gas extraction using modern hydraulic fracturing technology, especially in areas of the United States with limited or no recent history of oil and gas activity, has raised concerns regarding the potential environmental and health impacts of expanding oil and gas production on groundwater and surface water quality, public and private water supplies, and air quality. Concerns regarding water resources are understandably greater in areas with large population demands for water and/or areas facing possible water supply issues due to drought or other climate-related factors. The Water Research Foundation, in conjunction with the American Water Works Association (AWWA) and Ground Water Protection Council (GWPC), convened a workshop in 2014 to develop water and oil & gas sector partnerships. This workshop built on the information exchanged and collected during the original workshop from 2010 and the various related efforts by different organizations since then. The objectives of the workshop are: (1) for each sector to gain a better understanding of the other sector's operations, particularly on water management; (2) to improve communications and partnered responses to emergency situations such as spills; (3) to better understand monitoring strategies and needs, and (4) to share the latest research results and current practices in water management, emergency response, and water monitoring. This paper will present the findings of the workshop and a number of work products associated with the workshop.

Abstract 15

Utilizing Petrophysical Log Data to Map the Pennsylvanian Stratigraphy and the Depth to Base of Treatable Groundwater in a Complex Fluvial System

Laura Erichsen, Chesapeake Energy

Laura Erichsen is a hydrogeologist at Chesapeake Energy in Oklahoma City, which she joined in 2013. She graduated with a B.S. in Geoscience in 2010 from Northland College and is currently attending Oklahoma State University for a Master's degree in Hydrogeology. Laura is a former field geologist for Nomac Services, LLC with experience on drilling rigs in Pennsylvania, West Virginia, and Ohio. She also conducted pre-drill baseline water sampling for Chesapeake Energy while working for Groundwater and Environmental Services in West Virginia. She is currently studying the Pennsylvanian stratigraphy and hydrogeology of eastern Ohio for her Master's thesis.

Carroll County in Eastern Ohio overlies the western portion of the Appalachian Basin and is covered at the surface with Pennsylvanian fluvial-dominated sediments. These sediments extend to approximately 1000 feet below land surface and include sandstones, claystones, and coals that interfinger, creating complex geometries in the stratigraphy and freshwater-saltwater interface in this interval. The Ordovician Utica/Point Pleasant shale has become a prolific liquids-rich natural gas play in this area over the last several years. This has resulted in hundreds of new wells and a renewed focus on environmental stewardship and regulation. In this complex stratigraphy, a need has arisen to better define freshwater resources in the area in order to best protect aquifers. The state of Ohio defines treatable water as fluids containing less than 10,000 ppm total dissolved solids (TDS) and has mapped the depth to the base of treatable water (BTW) over most of the state. The portion of the map that covers Eastern Ohio, created in 1982, uses a Pennsylvanian stratigraphic marker as a proxy for the BTW and only covers the northern half of Carroll County due to increasing geologic complexity to the south. The new drilling in the area has created an abundance of comprehensive shallow petrophysical well log data that include the Pennsylvanian interval, allowing both a more accurate geologic model of the shallow intervals and determination of the BTW through direct calculations from log curves. This study of Carroll County aims to 1) delineate the shallow stratigraphy using well logs in order to revise and complete the Pennsylvanian stratigraphic model, and 2) identify and map the BTW based on the 10,000 ppm TDS regulatory cutoff using shallow petrophysical log data. The results are expected to show that a stratigraphic marker is an inaccurate way to define the BTW in this area.

Abstract 16

Protecting Groundwater in the Powder River Basin, Wyoming: Using Geophysical Logs to Map Confining Units and Ensure Surface Casing Isolation

Carly Sowecke, M.S., P.G. and Laura Erichsen

Ms. Sowecke completed her B.S. in Geology from Stanford University in 2007 and her M.S. in Geology from the University of Wyoming in 2010 (Thesis: Sego Sandstone in NW Colorado). Upon graduating with her M.S., she worked at an environmental consulting firm in Wyoming, where she designed and implemented baseline water quality sampling programs for operators. Currently, Ms. Sowecke is on the Hydrogeology Team at Chesapeake Energy, where she has worked since 2014. Her primary focus is on proactive risk management for aquifers and water resources in current development areas. Additionally, she is a registered Professional Geologist in Wyoming.

Ms. Erichsen completed her B.S. in Geoscience from the Northland College in Ashland, WI. She is currently working toward her M.S. in Geology at Oklahoma State University. Prior to working at Chesapeake, Ms. Erichsen worked as a field geologist for Nomac Services and at an environmental consulting firm in West Virginia. Since commencing work at Chesapeake in 2013, Ms. Erichsen has completed projects related to aquifers in eastern Ohio, Pennsylvania, and Southeastern Colorado.

The Powder River Basin (PRB) in Wyoming has a long history of oil and gas development, though the recent increase in unconventional horizontal drilling has brought more attention to environmental and water resources in the area. Previous studies in the PRB have focused on water resources along the outer extents of the basin or in areas near coal bed methane development in the north, but few studies have concentrated on mapping the detailed stratigraphy of the water-bearing geologic formations and the confining units in the southern PRB. We will focus on the use of geophysical logs to define and map regional confining units; units that prevent significant vertical migration of natural gas and deeper water into shallow, fresh water aquifers. Specifically, we will concentrate on the petrophysical criteria for picking the tops of beds from the Fox Hills Fm. to the Wasatch Fm. We will also address how we defined the important regional confining unit: the Lebo Member of the Fort Union Formation. The confining units are important for ensuring that the surface casing of unconventional gas wells is set at the correct depth to properly isolate shallow, fresh water aquifers from salt water and petroleum zones below. Overall, having more knowledge about the extent, thickness, and geologic characteristics of the confining units contributes to regulatory and drilling best practices.

Abstract 17

Methane occurrence and water-quality characteristics found in groundwater of the Appalachian Basin

Bert Smith - Chesapeake Energy Corporation

Review of analytical data from over 19,000 pre-drill groundwater samples collected on behalf of Chesapeake Energy Corporation from water wells in the Appalachian Basin indicates that methane is found naturally and is essentially ubiquitous in groundwater of the Appalachian Basin. The occurrence of methane is controlled by the hydrochemical facies (e.g. Na-Cl, Na-HCO_3, or Ca-HCO_3 groundwater type), whether the well is located in a valley or an upland location, whether the water well intersects restricted or confined saline zones, position of the well in the groundwater circulation system, and in some cases by the geological unit penetrated by the water well. Chesapeake's dataset also shows natural pre-drilling exceedances of water-quality standards (excluding turbidity) occur in 62.1% of water well samples in NE Pennsylvania and 87.3% in a Western Area of the Appalachian Basin(Eastern Ohio, Northern West Virginia, and SW Pennsylvania).

Bert Smith has over 35 years of experience as a hydrogeologist and works for the EnviroClean Group, an oil-field consulting and remediation company. He has a BS Degree in Geology and an MS Degree in Engineering from Washington State University. Mr. Smith has been responsible for coordinating the evaluation of Chesapeake's pre-drilling water quality data collected in the Appalachian Basin.

Abstract 18

Temporal Changes in Methane Concentrations in Shallow Groundwater, Appalachian Basin, Northeast Pennsylvania

Mark Becker of Chesapeake Energy

Unconventional natural gas produced from the Marcellus Shale Formation (Devonian age) in the Appalachian Basin of northeastern Pennsylvania has raised concern over produced methane gas contaminating shallow groundwater. Methane in groundwater in NE Pennsylvania has long been recognized by water-well drillers and researchers (Lohman, 1939). We selected 12 domestic water wells for inclusion in a temporal field study. Water wells were selected in Bradford and Sullivan Counties, Pennsylvania based on the results of initial baseline sampling; water wells were selected to include those wells sites with “low concentrations” of dissolved methane (<5 mg/L), those wells with “moderate concentrations” of dissolved methane (5-15 mg/L), and those wells with “high concentrations” of dissolved methane (>15 mg/L). Temporal variability, such as seasonally induced changes caused by climatic factors leading to natural fluctuations in areal groundwater levels, as well as water-well usage leading to significant or sustained well drawdown, resulted in substantial changes in dissolved methane concentrations in groundwater and/or headgas concentrations in the well annulus. Comparison of dissolved methane concentrations in study wells and corresponding water levels in USGS monitoring well, Br-92, also showed a significant correlation. Half the wells had significant correlation ($p \leq 0.05$) where dissolved methane concentrations fluctuated inversely to groundwater level changes. The significance of identifying this relationship with dissolved methane concentrations and water levels is extremely important for regulatory purposes. Setting response thresholds for a single dissolved methane concentration in a sample from a water well may create false positives or negatives depending on the amount of drawdown and regional water levels.

Abstract 19

A New Day for Alabama Groundwater Sustainability and Management: Science, Data Management, and Political Will

Marlon Cook, Geological Survey of Alabama

Marlon Cook is Director of the Groundwater Assessment Program at the Geological Survey of Alabama, He earned Bachelor of Science in Geology and Masters of Science in Hydrogeology from the University of Alabama. He worked for 8 years as an Exploration Geophysicist in oil and gas exploration and 25 years as a Hydrogeologist with the Geological Survey of Alabama involved in research to protect and develop the ground-water and surface-water resources of Alabama He currently serving on the Alabama Water Agencies Working Group, a committee commissioned by Governor Robert Bentley to establish a Water Resources Management Plan for Alabama.

Alabama is blessed with abundant groundwater resources from 25 major aquifers that provide public water supplies for more than 70% of the geographic area of the state. During the past 10 years, drought, periodic water shortages, and economic growth in Alabama have alerted water supply systems, agricultural interests, local governments, and state agencies to the need for plans to assure sustainability of future water supplies. Alabama Governor Robert Bentley and the Permanent Joint Legislative Committee for Water Policy and Management have joined to initiate the development of a water resources management plan for Alabama. These state leaders understand that effective water management and policy must be based on sound scientific data. Therefore, the Groundwater Assessment Program at the Geological Survey of Alabama has been mandated to conduct a comprehensive statewide assessment of groundwater resources. This assessment includes 15 hydrogeologic elements that form a comprehensive evaluation of groundwater availability and sustainability that will guide future water management, policy legislation, and development of groundwater resources in Alabama. More than 100 years of water related data, including more than 125,000 well records are included in the assessment. Concurrently, the Ground Water Protection Council is assisting the Geological Survey with development of an RBDMS-Environmental interactive database to store and analyze Alabama’s hydrogeologic data. These groundwater resource initiatives point to a new day for Alabama water resource management that will insure the sustainability of Alabama’s critical groundwater resources.

Abstract 20

Modeling of Pressure Propagation from Saltwater Disposal Wells Completed in the Arbuckle Group, northern Oklahoma

Kyle E. Murray, Oklahoma Geological Survey

Dr. Kyle E. Murray is a Hydrogeologist for the Oklahoma Geological Survey (OGS) and Adjunct Faculty for the ConocoPhillips School of Geology and Geophysics at the University of Oklahoma (OU). He investigates physical and chemical properties of geologic materials that store and produce fluids, and tends toward regional-scale studies of water, earth, and environmental resources. Water management in the energy industry is currently his primary research area, which includes study of water use in exploration and production, co-production of petroleum and water, saltwater management, disposal, recycle, and reuse.

The Arbuckle Group, a predominantly carbonate deposit, is the main zone for disposal of wastewater that was co-produced from petroleum wells in Oklahoma. Bottom-hole pressure data from over 1100 drill-stem tests collected over several decades indicates that the Arbuckle was underpressured when wells were completed. Sixty percent (60%) of the Arbuckle saltwater disposal (SWD) wells operating in Oklahoma from 2010–2013 were reportedly functioning with negative wellhead pressure, which suggests that the majority of the Arbuckle is still underpressured. The purpose of this study was to improve our understanding of pressure change in the Arbuckle as a result of fluid production or injection. A groundwater model was constructed and used to simulate spatial and temporal distribution of pressure under nine different scenarios or hydrogeologic conditions. The model scenarios indicate that pressure at the fault zones may increase substantially within a 6-mile radius of the SWDs, a radial distance around a SWD well that is examined for seismicity when invoking the 'Traffic Light System'. Injection scenarios show that fluid pressure in the Arbuckle is propagating both laterally and vertically (downward) away from the SWD wells and into the granitic basement as opposed to upward into the Simpson Group. Modeling also demonstrated that pressure may increase by a factor of two or more when a fault zone is represented as a barrier to flow using a relatively low permeability. Conversely, pressure at the fault zones may substantially decrease due to production from the Arbuckle. Other scenarios indicate that well depth, length of open interval, and completion type will have a substantial effect on pressure changes in the Arbuckle and overlying or underlying zones.

Abstract 21

Quantifying the Potential Impact of Oil and Saltwater Spills to Oklahoma's Water Resources

Glenn Brown and Nelly Ruiz, Oklahoma State University

Recent increases of oil and gas production in Oklahoma has raised concern about contamination to surface and ground waters. While there are anecdotal accounts of water pollution and much speculation of potential hazards, there are few quantitative accounts of actual or potential impacts to the state's waters. However, by combining currently available information from the Oklahoma Corporation Commission (OCC), the Oklahoma Water Resources Board (OWRB) and the Oklahoma Department of Environmental Quality (DEQ), it is possible to offer an informed perspective of past events and future risks. The OCC records and addresses drilling complaints through their Risk Based Data Management System (RBDM). With the RBDM it was possible to locate 99 recent complaints with saltwater or oil spills. Those locations were then correlated with the OWRB mapping of vulnerable aquifers based on the DRASTIC model, and it was found that 13% occurred over very vulnerable aquifers. Complaints were also compared to DEQ mapping of public water supply (PWS) intakes. Only one spill was located within three miles of a PWS intake. This analysis demonstrates that current oil and gas production does impact surface and groundwater resources, but that only a small percent of the recent spills had the potential for serious consequences. Future impacts may be mitigated further if the OCC were to integrate the OWRB and OCC databases into the RBDM.

Abstract 22

Innovative Process to Recycle Shale Gas Produced Water Utilizing By-Product Recovery Eliminating Disposal via Deep Well Injection

Tom Lewis, Lewis Environmental Services, Inc.

Mr. Lewis is President and Chief Technology Officer of Lewis Environmental Services and a graduate of Carnegie-Mellon University with a B.S. in Chemical Engineering. He has over thirty-six (36) years of technical expertise in the areas of environmental, energy and resource recovery technologies. He is a leader in using activated carbon for nontraditional applications and has successfully treated over 500,000,000 gallons of waste water with this core technology. He is currently commercializing the patented process known as the "ENVIRO-SHALE PROCESS" to recycle and reclaim frack and produced waters from shale gas operations. The company offers fixed site treatment and mobile recycling services.

Mr. Lewis' presentation will summarize mobile field treatment results upgrading shale gas waste water via the ENVIRO-SHALE Process (ESP) and by-product recovery. The case study will highlight the successful recovery of salable inorganic by-products such as barium, strontium and calcium and upgraded quality effluent as an alternative to disposal via deep well injection. The ESP effluent was tested and met water requirements to supplement fresh water volumes to drill new wells. The presentation will highlight the improvements in water quality and analysis of recovered by-products. Economic advantages of recycling shale gas waste water over disposal via deep well injection will be reviewed.

Abstract 23

Groundwater Management Decisions – Good Data leads to Good Decisions

Derek Smithee, Oklahoma Water Resources Board

Derek Smithee has been the Water Quality Programs Division Chief of the Oklahoma Water Resources Board since 1995 and been "doing" water with the State of Oklahoma since 1984. He is responsible for both surface and groundwater monitoring programs, Water Quality Standards, and Lakes studies. He has served in various capacities with the Association of Clean Water Administrators, the Groundwater Protection Council, the WQS Managers Association and many others. He received his BS from Oklahoma State University in 1984 and his MS from the University of Oklahoma in 1987. He is very active outside of work with the Oklahoma Aquarium, Oklahoma 4-H Foundation, OKC Memorial Museum, and the First United Methodist Church in Edmond. He also loves to travel on SCUBA junkets around the world and raises tortoises and several species of lizard.

Water management decision-making is a complicated and challenging endeavor as it deals not only with science, but public policy. Like many states, Oklahoma was historically driven to make myriad water management decisions based almost exclusively on policy as limited data was available to frame the decision-making process. This was especially true for groundwater. Clearly data is not required to make decisions – but it IS required to make GOOD decisions. Compounding the problem is that most water professionals have more of a scientific bend than a policy bend - with little training on dealing with people, policy setting, rulemaking or negotiation. This lack of real world, real time, relevant data, lead Oklahoma to make management decisions that in hindsight may not have been the best. Even so, these philosophical management decisions made blind to data may have been fine when they were first implemented in the 1950's, but may not reflect the best decisions today given changing technology, demographics, climate, and environment.
During Oklahoma's recent Comprehensive Planning Process, this foundational data need was clearly articulated from both the professional and public sector - and lead the Oklahoma Legislature to fund Oklahoma's first holistic groundwater monitoring program. This talk will focus on how Oklahoma conceived, executed and ultimately adopted the Comprehensive Water Plan through the lens of monitoring and data. It will also explore how other states might benefit from a similar process – including critically important elements and pitfalls to avoid.

Abstract 24

Hydraulic Fracturing Chemicals Reporting: Analysis of FracFocus 1.0 and 2.0

Kate Konschnik, Harvard Law

In 2014, Groundwater Protection Council began work on a new round of upgrades (FF version 3.0) to launch in 2015. The Harvard Environmental Policy Initiative was invited to participate. As part of this work, we proposed an analysis of FF 1.0 and 2.0 forms to respond to the SEAB Task Force's call for an audit of FracFocus. (SEAB 2014) GWPC agreed to share all available SQL data from the registry so that we could conduct our proposed analyses. As of May 7, 2015, this aggregated data set is available to the public on FracFocus.org, enabling researchers to download and analyze data across wells.

We set out to use the aggregated data to determine when disclosures were made, quantify certain data errors, and calculate the rates of missing data (whether "not available" to data entry personnel at the time of submission, or withheld by a company asserting proprietary concerns). Our analyses provide a snapshot of the data for researchers, and establish a baseline for comparison with data submitted to FracFocus after the 2015 upgrades.

We also set out to compare results over time and between states and large service companies, to note any correlations that might exist between different requirements and reporting practices on the one hand, and rates of timely, higher data quality and more complete disclosure on the other. This could suggest requirements and practices that produce the most accurate and complete information for states and the general public.

Kate Konschnik is the founding Director of Harvard Law School's Environmental Policy Initiative (EPI), a policy shop providing real world legal analysis of hot topics in energy and climate. EPI has worked with and presented research to state and national organizations including the National Research Council, the National Governors' Association, the Midwestern Power Sector Collaborative, and the United States Secretary of Energy's Advisory Board.

Previously, Kate served as Chief Environmental Counsel to a U.S. Senator and directed his subcommittee on the Senate Environment and Public Works Committee. From 2002 to 2009, Kate also served as a trial attorney at the U.S. Department of Justice.

Abstract 25

Water Use by Sector: An Analysis of FracFocus and USGS Water Use Data

Mike Nickolaus, Ground Water Protection Council, Oklahoma City, OK

It has often been said that hydraulic fracturing uses a relatively small amount of water when compared to other uses. Clearly, high volume horizontal well hydraulic fracturing is a relatively minor user of water at the national level, accounting for less than 0.2% of water use when compared to other consumptive water uses such as irrigation and public water supply. However, the question remains as to whether or not this ratio of usage between sectors remains consistent down to the local level. In this presentation we will discuss the findings of a comparative analysis of water use in the sectors of irrigation, public water supply, and hydraulic fracturing at decreasing geographic scales in three oil and gas producing states (Texas, Pennsylvania, North Dakota) to determine whether or not the relationship between water usage in these sectors remains relatively static from national to county levels. Further we will evaluate the relative use between states to determine what effect substantial reuse of water for hydraulic fracturing has on overall consumptive water use when compared to other sectors. To analyze water usage across the three sectors, data from USGS water use publications and the FracFocus© chemical registry were utilized. Where unique state or regional conditions might apply, additional information from state regulatory agencies was utilized to ensure that water usage was consistent with agency figures.

Mike is the Special Projects Director for the Ground Water Protection Council. He is the former director of the Indiana Department of Natural Resources, Division of Oil and Gas. Mike has worked in the field of geology for nearly 30 years. He is a Professional Geologist and Member of the Society of Petroleum Engineers.

Abstract 26

Is Texas the Next Global Leader in Energy-Water Planning? Clean Technology and Data Hold the Answer

Kate Zerrenner, Environmental Defense Fund

Kate Zerrenner leads EDF's efforts to influence and enact state and national energy and water efficiency policy, including breaking down financial, regulatory, and behavioral barriers. Her expertise includes technologies and policies affecting traditional energy generation, energy efficiency business models, and the energy-water nexus. She serves on the City of Austin Integrated Water Resource Planning Community Task Force and the Advisory Board of the Smart Cities Council. Previously, Kate worked at the U.S. Government Accountability Office, U.S. Department of Energy, the U.S. Department of Defense, and the Texas Legislature. She holds Master's degrees from Johns Hopkins and the University of Glasgow, and a Bachelor's degree from the University of Texas.

Using Texas as a case study, Kate will discuss the inextricable link between energy and water, as well as the need to harness data and technology to spark both behavioral changes in Texans and better coordination between the two sectors for long-term planning.
Texas is in the midst of a multi-year drought, yet the vast majority of the electricity Texans use comes from sources that require copious amounts of water (namely, coal and natural gas). Across the nation, roughly 90 percent of current energy use comes from nuclear or fossil fuel power plants, which requires 190 billion gallons of water per day or 39 percent of all U.S. freshwater withdrawals. Further, while coal uses about three times more water than more efficient natural gas plants, both drain strained water resources in Texas.

Conversely, wind and solar energy and energy efficiency consume little to no water, as well as generate negligible carbon emissions. Already an international leader in energy, Texas can increase its use of clean energy resources to cope with the continuing drought and growing need for electricity (and water). Additionally, the water sector can achieve greater energy efficiency savings at a lower cost than traditional electric utility programs.
Citing specific pilot and demonstration projects, in Texas and elsewhere, Kate will help audiences understand how people, businesses, and government can adopt and adapt to the new technology landscape to increase energy and water efficiency. Moreover, they will learn how this information can drive greater coordination in planning for both the energy and water sectors.

EDF looks forward to the opportunity to share insights on how water data and clean energy can help lower utility bills, conserve during the driest of droughts, reduce carbon emissions, and ultimately make the U.S. a global leader in energy and water.

Abstract 27

Aquifer Recovery in South Arkansas and North Louisiana through Public Policy, Science, Monitoring and Partnerships

Patrick J. Higgins, Burnes & McDonnell Engineering Co.

Mr. Higgins is an Associate Hydrogeologist with Burns & McDonnell Engineering Co., 9400 Ward Parkway, Kansas City, MO 64114. He has led numerous hydrogeological investigations, applying field methods, aquifer analysis, and groundwater flow modeling, culminating in development of reliable groundwater supplies for municipalities and industry. Additionally, Mr. Higgins supports other projects performed by the Water Global Practice at his firm, including water master plans, seepage analysis, and dewatering design.

Prior to October 2004, the Sparta aquifer supplied all drinking and industrial water in Union County, Arkansas. Seventy years of excessive withdrawals exceeding aquifer recharge rates had led to groundwater declines of more than 360 feet, forming deep cones of depression and threatening water supply and quality.
In January 1996, Arkansas declared five South Arkansas counties the state's first Critical Groundwater Area. USGS flow models indicated the County's sustainable yield was approximately 7 million gallons per day (mgd), a 72 percent reduction in its 21 mgd 1997 withdrawal rate.
Following intensive countywide public/private collaboration, stakeholders supported legislation creating the state's first Critical Groundwater Conservation Board, the Union County Water Conservation Board, in June 1999. The Board immediately hired an engineering firm to explore solutions and by December 2005 had

built and paid for the $65M Ouachita River Alternative Water Supply Project providing major industry with Ouachita River surface water and reducing groundwater withdrawals by about 7.5 mgd. This and other efforts reduced groundwater consumption by 52 percent.
In 2002, the Board began monitoring aquifer water level and quality response in a 45+/- mile radius, which is critical to evaluating project success and ongoing decision-making.

Since October 2004, groundwater levels have risen significantly, with one well nearest the deepest cone of depression having risen 73.9 feet, also reducing the threat of water quality degradation.
A 2012 aquifer test indicated that historical pumping has not reduced the aquifer's ability to recharge, store, or deliver water. Compaction or other damage had not occurred, but surely would have had heavy pumping continued. Through its collaborative efforts, Union County avoided a calamity -- irreversible aquifer damage. The Board now provides an affordable alternative surface industrial water source, conserving Sparta water for drinking.

Abstract 28

Stream Monitoring for Evaluating Groundwater Methane Associated with Shale-Gas Development

Victor Heilweil, University of Utah

Vic earned his Ph.D. Geology from the University of Utah and is currently a Research Hydrologist with the U.S. Geological Survey. His overall focus is the combined use of isotopic/dissolved-gas tracers and multiphase modeling for investigating groundwater flow and quality. Current research includes investigating natural and managed aquifer recharge in arid settings; and developing stream-based hydrocarbon monitoring techniques for evaluating potential groundwater impacts from unconventional oil and gas development. Vic currently serves as President of the U.S. National Chapter of the International Association of Hydrogeologists and is an Adjunct Professor at the University of Utah.

Environmental impacts of shale-gas development, including methane migration into shallow groundwater, have been difficult to assess. Monitoring around gas wells is generally limited to domestic water-supply wells, which often are not situated along predominant groundwater flow paths. A new method combines stream hydrocarbon and noble-gas measurements with reach mass-balance modeling to estimate thermogenic methane concentrations and fluxes in groundwater discharging to streams. Gas tracer experiments in both Utah (Nine-Mile Creek) and North Carolina (West Bear Creek) demonstrated that injected CH_4 persisted downstream at the kilometer scale. It is assumed that stream methane eventually exsolves to the atmosphere as a greenhouse gas. But in the West Bear Creek experiment, injected krypton indicated that a significant fraction of the downstream decline was from microbial oxidation of CH_4. In a pilot study in the Marcellus Formation shale-gas play in northern Pennsylvania, sampling in 15 watersheds identified four streams with elevated methane. Detailed geochemical characterization of one of these streams, Sugar Run, is consistent with a thermogenic Marcellus Formation gas source. Numerical stream-transport modeling indicates CH_4 is discharging along a 4-km reach of Sugar Run at about 1 kg d^{-1}. The Pennsylvania Department of Environmental Protection Violation letter has noted that several domestic water wells were impacted by stray gas migration near a gas well drilled horizontally beneath Sugar Run noted to have defective casing or cement. This is a possible source of thermogenic methane to the stream. Due to the coalescing of flow paths in gaining streams, such monitoring provides an integrated signal of groundwater quality. The approach offers the first watershed-scale method for identifying locations where shale gas is migrating into shallow freshwater resources. While it has only been applied thus far in the Appalachian Basin (Eastern U.S.), it could be utilized anywhere unconventional shale-gas extraction is either ongoing or under consideration.

Abstract 29

ASR Status in the United States

Fred Bloetscher, Florida Atlantic University

Dr. Bloetscher is an Assistant Professor at Florida Atlantic University in Boca Raton, Florida, and also the President of Public Utility Management and Planning Services, Inc., which he started in 2000. His interests focus on the planning and management water resource systems, including groundwater resource and risk projects. Prior to starting his own firm, he worked for local governments in utility management for 20 years.

This presentation updates the result of a survey of sites in the United States that are known to have investigated the concept of aquifer storage and recovery (ASR), based on conversations with regulatory personnel, consultants and literature reviews. A summary of current ASR statistics will be presented. Of interest is that the vast majority of sites use surface waters for injection fluids but reclaimed water use is expanding; alluvial and limestone are popular injection horizons, but most to the northwest systems are basalt; the wells are largely confined, but California wells may not be; steel is the most common casing type; and a third of the systems are no longer utilized. However only about 35% of total sites are currently operating injection and recovery programs. A large number are in test mode, some having been there for many years. A percentage of site are not active due to clogging, recovery and water quality issues. These inactive projects could be pursued in some cases if geophysical and regulatory issues are barriers to overcome.

Since the 2013 survey in many years, ASR programs continue to evolve and status change as regulatory requirements, demand and financial positions change. Florida and Georgia are two states where regulatory issues remain driving forces for ASR moving forward. The 2015 Georgia Legislature discussed the ban on ASR, and legislation was introduced to continue the ban despite pleas from water resource officials in the Flint River basin who proposed an ASR facility there. In Florida, a number of ASR facilities are inactive due to issues with arsenic. Bradenton has continued to investigate issues with ion exchange as a means to reduce arsenic. Collier County addressed arsenic on their north district ASR plan. And FDEP and USEPA agreed to address the metals issue on a case by case basis for potable ASR wells only. FDEP has issued several stalled permits as a result.

Abstract 30

Shale Energy Produced Fluids Management and UIC Well Disposal Trends

David Yoxtheimer, Penn State University's Marcellus Center for Outreach and Research

David Yoxtheimer, P.G. is a hydrogeologist and extension associate with Penn State University's *Marcellus Center for Outreach and Research* and serves as a liaison to advise stakeholders on key environmental issues. He earned his B.S. in Earth Science from Penn State, where he is currently completing his Ph.D. in Geosciences. Previous to joining MCOR he spent 18 years as a consulting hydrogeologist with expertise in water supply development, karst hydrogeology, geophysical surveying, environmental permitting, shale energy geology, and integrated water resource management. Dave was recently appointed as a Technical Advisory Board member for the Pennsylvania Department of Environmental Protection to assist with development of new oil and gas regulations.

Shale oil and gas production in the United States has been increasing significantly over the last decade, especially from the Bakken (North Dakota), Marcellus (Pennsylvania/West Virginia), Utica (Ohio/Pennsylvania), Eagle Ford (Texas) and Niobrara Formations (Colorado). Water management challenges including sourcing, transport, and brine disposal exist with development of these resources and vary from basin to basin. Large volumes of produced brines are generated after a well has been hydraulically fractured, typically ranging from 5 to 10 barrels of brines per million cubic feet of gas or for each barrel of oil produced. Managing these produced brines requires environmentally-sound, long-term approaches for treatment, reuse or disposal and is a key factor to ensure domestic energy production can continue to grow. Data indicate that produced brines from many shale plays around the U.S. are primarily disposed of via UIC wells rather than recycled, largely due to the availability and relatively low cost of using brine disposal wells in these regions. Most shale plays are seeing increased rates of recycling, and operators in Pennsylvania have demonstrated that 85% or more of the brines can be recycled for hydraulic fracturing. The recent drop in oil and gas prices will also be considered, which has resulted in decreased drilling and fracturing activities in the U.S. in the short term and therefore may reduce brine recycling initiatives resulting in increased use of brine disposal UIC wells. This presentation will explore the volumes of produced fluids generated from major shale energy plays and examine treatment and disposal practices including UIC well use and implications for future disposal reservoir capacity as shale energy production continues into the future.

Abstract 31

How Leadership Changes Affect Sustainability Measures of Public Water Systems

Lauren Behel and Alan Barefield

Lauren Behel is an Extension Associate with the Mississippi State University Extension Service and coordinates various components of the Mississippi Public Water System educational program, including coordinating and providing curricula for board management training, tracking continuing education units for certified operators, and providing analysis and technical assistance for public water systems in Mississippi. Alan Barefield is an Extension Professor with Mississippi State University and directs the Public Water System educational programming efforts housed within the Agricultural Economics department. His primary areas of responsibility are in the areas of firm and regional economic analysis and strategic planning.

Public water systems face mounting challenges including limited funding, deteriorating assets, increasing regulatory scrutiny, and an aging and retiring workforce. Also, frequent differences of opinion between management and the workforce limit efforts to manage water systems efficiently. Many operators and board members face one urgent priority after another, leaving little time for developing effective working relationships to improve production and services for the community. Considering these various difficulties, changes in leadership of all types may have the most direct impact on the sustainability of public water systems. According to the California Department of Water Resources, "sustainability" has been widely used in recent years to describe a variety of planning activities while giving no real definition to the word. A system that is sustainable should meet the product demand of the community without compromising or limiting the practical and economic future of the water system.

Using various sustainability measures, including capacity assessment scores and individual system financial standing, this presentation analyzes the positive and negative influence of changes in leadership on the success of public water systems. Do frequent changes in leadership limit opportunities for operators, managers, and owners to collaborate on issues that affect the viability of water systems? Do frequent operator turnovers influence the success of public water systems in increasing capacity assessment scores to acceptable levels? The analysis focuses on the change in the water system's human capital (operators, board members, and responsible officials) to determine the impact of human capital on a variety of measures that contribute to the notion of the individual system's sustainability.

Abstract 32

A Best Practices Manual for Outreach & Education to Private Well Owners

Steve Wilson

A manual for field practitioners who work with private well owners was developed to provide suggestions, ideas, and best practices for engaging and educating private well owners. The manual was developed based on interactions with nearly 100 sanitarians, educators, and groundwater professionals who work with private well owners on a daily basis. The manual provides their insights and experiences, and well as information gleaned from the health risk communication literature. The manual provides an approach to running an outreach program, as well as discusses how to overcome common barriers we all face in dealing with private well owners who may not understand the importance of their well.

Steve Wilson, Groundwater Hydrologist, State Water Survey, University of Illinois

Abstract 33

Spill Response in Ohio: Practical Guidance for Operators of Horizontal Oil and Gas Wells

J. Daniel Arthur, P.E., SPEC; **Kris Andersen,** David Bockelmann, Kevin Shepard, ALL Consulting

Kris Andersen is a Senior Environmental Consultant with ALL Consulting. He has a Bachelor of Science degree in Geological Engineering from the Missouri University of Science and Technology. Mr. Andersen has over 28 years of diverse experience in safety, environmental and regulatory project management and consulting.

Mr. Andersen has supported oil and gas clients with their operations in Ohio, Pennsylvania, North Dakota, Texas, Louisiana, Kansas, and Oklahoma. He has served as a Spill Coordinator, responding to hundreds of spills on and off oil & gas well pads, with response costs ranging up to $3 million. Mr. Andersen formerly served as a senior environmental regulatory specialist and was accredited as a Master level Certified Hazardous Materials Manager. He directed and oversaw compliance and cleanup activities under enforcement agreements, participated in radioactive and hazardous materials remediation work, prepared hazardous waste permit applications, developed UST compliance programs, and developed multi-program compliance initiatives. Mr. Andersen is a former U.S. EPA hazardous waste inspector and conducted investigations in preparation for and as a part of enforcement proceedings. He has also been a Certified Environmental Trainer, and has developed and delivered training on SPCC, HAZWOPER, OSHA Hazard Communications, and RCRA.
Mr. Andersen currently manages ALL's office in Cadiz, Ohio, providing oversight and direction to ALL staff supporting clients in the eastern US as well as serving as the company representative to regional clients and regulators.

Across the United States, oil and gas operators experience thousands of spills annually on exploration and production (E&P) well pads. Virtually any material brought to or produced on an oil and gas well pad can be spilled during drilling, completion, and production operations. Typical materials on a well pad may include: diesel fuel, drilling mud and additives, frac fluid, acid, brine, potassium chloride, crude oil, condensate, etc. Requirements for reporting and responding to these spills vary from state to state, ranging from very prescriptive directives to general, performance-based objectives. This presentation provides an overview of the regulatory framework, and some practical considerations for oil and gas operators responding to spills at well pads in Ohio. This presentation discusses spill reporting, spill characterization, response resources, effective cleanup and remediation strategies, and alternatives; while working effectively to address health and safety concerns with DOGRM, the public, and other community stakeholders.

Abstract 34

CLASS II DISPOSAL WELL BEST MANAGEMENT PRACTICES WORKSHOP

Dan Arthur, ALL Consulting

This course will focus on understanding the key aspects of Class II injection well disposal, and will address some of the challenges facing the Class II injection well industry. Class II saltwater disposal wells are an essential component of unconventional oil and gas development in the United States. For the last several years, public attention has been focused on hydraulic fracturing, but now some of that attention has focused on Class II injection wells, as issues such as ground water protection, potential injection-related induced seismicity, waste water radioactivity, and truck traffic have become more publicized. The Underground Injection Control Program is well regulated, but the use of best management practices (BMPs) can help to reduce public concerns and ensure protection of underground sources of drinking water.

TOPICS TO BE COVERED:

- History of the Class II Program
- Well Siting Considerations – Leasing, Mineral Rights Issues, Geologic Evaluation, Transportation Options and Site Access
- Area of Review, ZEI ,and Corrective Action

- Well and Surface Facility Permitting - Regulatory Framework, Permitting Requirements, Federal, State, and Local Government Oversight, Tribal Lands, Health & Safety Plan, USDW delineation, Aquifer Exemption
- Well Construction and Facility Design – "Best in Class"
- Well Drilling and Completion Practices – Cementing, Completion Methods, and Stimulation
- Injection Well Testing Requirements
- Operational Considerations – Environmental Compliance, Formation Damage, SPCC, Emergency Response Plans, Spill and Clean-up Remediation, Routine and Preventative Maintenance, Chemical Treatment and Filtering of Injectate
- Well Integrity and Well Workovers
- Financial Assurance
- Risk Considerations - Induced Seismicity and Seismic Monitoring, Accidents and Litigation, Public Opposition and Environmental Activism
- NORM/TENORM Issues – Solid Waste Disposal
- Well Closure – Plugging and Abandonment

This workshop is intended to be a comprehensive review of the key aspects of Class II disposal wells, and to provide attendees with a clear understanding of Class II disposal wells and their role in the development of our oil and natural gas resources.

Abstract 35

How Things Have Changed: Class II Disposal Wells and Unconventional Oil and Natural Gas Development

J. Daniel Arthur, P.E., SPEC; Thomas E. Tomastik; Greg Casey, P.E.; **H. William Hochheiser;** David Alleman; Fernando DeLeon; Chuck Lowe; ALL

H. William (Bill) Hochheiser is an environmental scientist with ALL Consulting, specializing in technical, environmental, and regulatory issues related to all facets of energy development. He has over 35 years of diverse experience in government service and consulting. His work has primarily involved research and analysis of the potential environmental impacts of oil and gas development, including impacts to surface water, groundwater, and air. Mr. Hochheiser has been involved with injection related issues for over 30 years, having worked on the initial regulatory determination for the RCRA Exemption, and the aquifer exemption rules. In addition, Bill helped to establish and manage programs that worked with states and EPA to document improvements in the states' management of oil and gas wastes through IOGCC's State Review Process and the STRONGER review process. He helped to establish the initial Risk Based Management System with GWPC, and currently serves as ALL's technical advisor RBDMS projects. Mr. Hochheiser also serves as the trainer and communications coordinator for the FracFocus database developed and maintained by ALL Consulting.

Class II injection wells have been an integral component of oil and natural gas development in the United States since the 1930's. Until recently, Class II injection wells were primarily tied to conventional oil and gas production, with most Class II injection wells being used for enhanced oil recovery. Unconventional wells continue to rely on Class II wells for disposal of produced water, but high volume hydraulic fracturing of tight formations results in a very different water production profile that requires proper chemical and filtering treatment prior to injection. As unconventional development has continued, the need for Class II disposal wells has increased, but these new disposal wells must be able to accommodate the associated changes in water disposal requirements and regulations. Additionally, public opinion and media attention regarding induced seismicity has made Class II disposal a nationwide issue.

This paper will examine how the use of Class II disposal wells has been evolving in response to unconventional oil and gas development, and will discuss what challenges are expected in the years to come. The paper will present a review of the history of Class II wells and the UIC Program in terms of the numbers of wells permitted, types of Class II injection wells permitted (Class IID vs. Class IIER), regulatory changes, and disposal volumes for selected plays. It will also address how unconventional oil and gas development has created changes in the use and operation of Class II disposal wells, and will present considerations for the future.

Abstract 36

Analysis of Hydraulic Fracturing Fluid Data from the FracFocus Chemical Disclosure Registry 1.0

Jeanne Briskin, USEPA

As part of its research on the potential impacts of hydraulic fracturing for oil and gas on drinking water resources, US EPA worked with the Groundwater Protection Council to obtain data from more than 39,000 disclosures in the Frac Focus 1.0 data base. EPA extracted and summarized data on the composition of hydraulic fracturing fluids to help address two research questions:

- What are the identities and quantities of chemicals used in hydraulic fracturing fluids, and how might this composition vary at a given site and across the country?
- How much water is used in hydraulic fracturing operations, and what are the sources of this water?

This talk will review the approach and key findings from EPA's analysis, as published in March 2015.

Jeanne Briskin is responsible for leadership, planning, coordination, and oversight of the US Environmental Protection Agency's research related to hydraulic fracturing. She leads the implementation of EPA's Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources. In her 30 years' experience at US EPA, Jeanne has also led programs and policy development at EPA in the areas of energy efficiency, drinking water, climate change, stratospheric ozone layer protection, pesticides, and hazardous waste. Jeanne received her BA in Chemistry and Environmental Studies from Northwestern University and MS in Technology and Policy from the Massachusetts Institute of Technology.

Abstract 37

Development and Implementation of the National Ground-Water Monitoring Network

Daryll Pope, New Jersey Water Science Center, U.S. Geological Survey

Daryll has a B.S. in Watershed Science from Colorado State University and a Masters in Contaminant Hydrology from Oregon Graduate Institute. Daryll has worked on groundwater studies and groundwater modeling throughout his career. He has been Groundwater Specialist at USGS New Jersey since 1995 and has been involved with the groundwater monitoring networks of the Science Center. Daryll has been involved in several studies looking at groundwater availability. Daryll worked on the NGWMN New Jersey Pilot and has been providing support for the NGWMN since 2010.

The Subcommittee on Ground Water (SOGW) of the Federal Advisory Committee on Water Information (ACWI) is working to develop the National Ground-Water Monitoring Network (NGWMN). The Network is focused on principal aquifers of the United States and is intended to provide data and information necessary for sustainable management of groundwater resources. The core of the Network will be long-term sites (trend sites) that represent conditions in the aquifers over time. These will be supplemented by sites that are measured or sampled less frequently but cover a greater spatial density (surveillance sites). Sites are classified within subnetworks to indicate the degree to which they have been affected by human activity. Data that are already being collected by various Federal, State, Local, or Tribal agencies provide a source of potential sites for the network. These agencies can take part in the Network as data providers. This involves selecting and classifying sites in their networks according to the NGWMN guidelines and setting up a connection for their data to the NGWMN data portal.

Funding to implement the Network became available in December 2014. The major focus for the first few years will be on expansion of the Network by adding new data providers. A request for proposals will be issued in the fall of 2015 through grants.gov for the competitive process to apply for funding as a data provider. The Network will be coordinated by three groups; the ACWI Subcommittee on Ground-Water provides general guidance and design of the network, the USGS is responsible for distributing funding and day-to-day management of the Network, and the NGWMN Program Board, which will be established in 2015 to represent the NGWMN data providers, will be involved in setting priorities and evaluating proposals for the Network.

Abstract 38

Hydrogeology, Distribution, and Volume of Saline Groundwater in the Southern Midcontinent and Adjacent Areas of the United States

By Noël I. Osborn, S. Jerrod Smith, and Christian H. Seger

The hydrogeology, distribution, and volume of saline water in 22 aquifers in the southern midcontinent of the United States were evaluated to provide information about saline groundwater resources that may be used to reduce dependency on freshwater resources. Those aquifers underlie six States in the southern midcontinent—Arkansas, Kansas, Louisiana, Missouri, Oklahoma, and Texas—and adjacent areas including all or parts of Alabama, Colorado, Florida, Illinois, Kentucky, Mississippi, Nebraska, New Mexico, South Dakota, Tennessee, and Wyoming and some offshore areas of the Gulf of Mexico. Saline waters of the aquifers were evaluated by defining salinity zones; digitizing data, primarily from the Regional Aquifer-System Analysis Program of the U.S. Geological Survey; and computing the volume of saline water in storage.

The distribution of saline groundwater in the southern midcontinent is substantially affected by the hydrogeology and groundwater-flow systems of the aquifers. Many of the aquifers in the southern midcontinent are underlain by one or more aquifers, resulting in vertically stacked aquifers containing groundwaters of varying salinity. Saline groundwater is affected by past and present hydrogeologic conditions. Spatial variation of groundwater salinity in the southern midcontinent is controlled primarily by locations of recharge and discharge areas, groundwater-flow paths and residence time, mixing of freshwater and saline water, and interactions with aquifer rocks and sediments.

The volume calculations made for the evaluated aquifers in the southern midcontinent indicate that about 39,900 million acre-feet (acre-ft) of saline water is in storage. About 21,600 million acre-ft of the water in storage is slightly to moderately saline (1,000–10,000 milligrams per liter [mg/L] dissolved solids), and about 18,300 million acre-ft is very saline (10,000–35,000 mg/L dissolved solids). The largest volumes of saline water are in the coastal lowlands (about 16,300 million acre-ft), Mississippi embayment and Texas coastal uplands (about 12,000 million acre-ft), and Great Plains (about 8,170 million acre-ft) aquifer systems. Of the 22 aquifers evaluated in this report, the Maha aquifer in the Great Plains aquifer system contains both the largest total volume of saline water (about 6,280 million acre-ft) and the largest volume of slightly to moderately saline water (about 5,150 million acre-ft).

Abstract 39

North Carolina's Private Water Well Construction Standards

North Carolina's Private Drinking Water Well Program – **Wilson Mize**, NC DHHS-DPH
Local Health Department Challenges and Successes in the Private Drinking Water Well Program – **Wilson Mize**, NC DHHS-DPH
Collaboration between Public Health and Environmental Agencies – Wilson Mize, NC DHHS-DPH and **Evan Kane**, NC DENR-DWR
Data Management Improvements to Support Private Well Programs- **Evan Kane**, NC DENR-DWR

Nearly one quarter of North Carolinians get their drinking water from private drinking water wells. Because of this heavy reliance on groundwater generally and private wells specifically, North Carolina has instituted a number of programs to help protect the health of private well users including statewide well construction standards, well contractor certification, and permitting and testing of all new private wells. In addition, there is extensive communication and collaboration between the state's environmental protection and public health agencies to address issues affecting private well users. These presentations will provide an overview of North Carolina's private well program including its successes and challenges, collaboration between the state's environmental protection and public health agencies, and data management improvements being instituted to help support the private well program.

Abstract 40

Understanding, Quantifying and Managing Risk from Injection-Related Earthquakes: A Case Study from Oklahoma

Rall Walsh, Randi J. Walters, Mark D. Zoback, Jack W. Baker, and Greg C. Beroza Stanford University

Over the past six years, the earthquake rate in the central and eastern U.S. has increased markedly, in many cases apparently related to fluid injection associated with oil and gas activities. Development of methodologies for understanding, quantifying and managing the risks these earthquakes potentially pose is a considerable challenge for both regulators and oil and gas operators. Nowhere has seismicity increased more markedly than in Oklahoma. In three study areas that encompass the majority of Oklahoma's recent earthquakes, we show that the increase in seismicity follows a significant increase in saltwater disposal that comes principally from produced water, saline pore water that is co-produced with oil and gas, then injected into deeper sedimentary formations. These deeper formations appear to be in hydraulic communication with potentially active faults in crystalline basement, where nearly all the earthquakes are occurring. Although the majority of the recent earthquakes have posed little danger to the public, the possibility of triggering damaging earthquakes on potentially active basement faults cannot be discounted. Going forward, we suggest a science-based method to characterize and mitigate the risk associated with injection-related seismicity. This includes a comprehensive geologic, hydrologic, and geomechanical site characterization and risk assessment, using Probabilistic Seismic Hazard Analysis (PSHA) as the foundation. In addition, we recommend use of a site-adaptable and proactive traffic light system. We encourage measures that are risk based, adaptable, goal oriented, and rely, to the degree possible, on well-established procedures and recommendations.

Rall Walsh is a 5th year Ph.D. candidate in the Stanford Department of Geophysics. He was the Teaching Assistant for Stanford's 2015 online offering of Reservoir Geomechanics, successfully completed by over 2,000 students from over 100 countries. Rall has interned in Geomechanical technology research units at two major energy companies, and collaborates with many others through the Stanford Center for Induced and Triggered Seismicity, and the Stanford Rock and Borehole Geophysics consortium.

Abstract 41

Produced Water Volumes and Management Practices

John Veil – Veil Environmental, LLC, Annapolis, MD USA

Until recently, the most detailed estimate for produced water volumes from all oil and gas wells in the United States had been made for the year 2007 (21 billion bbl). That report also gave general trends on how the produced water was managed (nearly all onshore produced water is reinjected, and nearly all offshore produced water is treated and discharged). However, that information is now somewhat dated. This presentation describes an updated version of a national produced water volume estimate and management practices for the year 2012. The new data compilation and report were prepared by Veil Environmental for the Ground Water Protection Council – the final report was issued in April 2015.

Since 2007, the U.S. oil and gas industry has changed dramatically with the rapid expansion of unconventional oil and gas production. Unconventional production was not a large percentage of total national production in 2007, whereas in 2012 unconventional production was considerably higher. The total volumes and changes over time in water production profiles are generally different for conventional wells and unconventional wells.

The most interesting finding from the report is that when total national volumes are compared for 2007 and 2012, the oil production increased by 29%, the gas production increased by 22%, but the water production increased by less than 1%.

John Veil is the President of Veil Environmental, LLC, which he founded upon his retirement from Argonne National Laboratory in 2011. Veil has published numerous reports on produced water and has lectured around the world on water and energy subjects. He holds degrees in Earth and Planetary Science, Zoology, and Civil Engineering. He is also an avid saltwater fisherman.

Abstract 42

Health Risks from Drinking Water Impacted by a Flowback Water Spill in the Marcellus Shale Region

William Rish, Ph.D. and Edward Pfau, M.S.**,** The Hull Risk Analysis Center

Dr. Bill Rish directs The Hull Risk Analysis Center (HullRAC), a team of experts at Hull & Associates that apply science and communication skills to support risk-based decisions. He has over 30 years of experience in risk assessment, decision analysis, and environmental consulting.

Dr. Rish has prepared hundreds of risk assessments and has been active for many years in the development of federal and state regulatory guidance on risk assessment and risk-based cleanup standards. He earned his doctorate in Engineering and Public Policy and his Bachelor of Science in Metallurgy/Material Science and Public Affairs (jointly conferred) from Carnegie-Mellon University.

One source of human health risk associated with shale gas development is possible exposure to chemicals present in a spill of flowback water from the horizontal hydraulic fracturing process. In 2009, the Gas Technology Institute (GTI) published the findings of sampling and laboratory analysis of flowback water from 19 shale gas wells drilled into the Marcellus Shale in Pennsylvania and West Virginia. The chemical analysis results from the GTI study are used in this paper to characterize the chemical composition of an assumed spill of flowback water. A risk assessment is presented that quantitatively evaluates possible human health risk from a hypothetical scenario where 10,000 gallons of this flowback water is spilled on the ground, infiltrates into groundwater that is a source of drinking water, and an adult and child located downgradient drinks the groundwater. Key uncertainties encountered when estimating risk are given explicit quantitative treatment using Monte Carlo Analysis. Chemicals significantly contributing to estimated health risks are identified, as are key uncertainties and variables to which risk estimates are sensitive.

The results indicate that spills of flowback water from Marcellus Shale hydraulic fracturing onto the ground surface are unlikely to pose a significant risk to adults or children drinking groundwater downgradient of the spill location. Predicted excess lifetime cancer risk levels from drinking water impacted by a flowback water spill are well-below accepted levels of concern. This includes evaluation of 21 carcinogenic chemicals that were detected in the flowback water samples. Predicted contribution to non-cancer health risks from drinking water impacted by a flowback water spill are generally at levels where no adverse health effect is expected, with the exception of low probability higher end exposure by children to lithium. However, regional naturally-occurring levels of lithium alone in groundwater are predicted to result in non-cancer health risks that exceed a generally acceptable hazard index of 1. Salinity taste thresholds are likely to be exceeded before drinking water exposures result in the possibility of adverse health effects. The results also indicate how improvement in the ability to estimate health risks from drinking water impacted by a flowback water spill (i.e., reducing uncertainty) can be achieved.

Abstract 43

Arkansas Oil and Gas Commission Abandoned and Orphan Well Plugging Program

Gary Looney, Arkansas Oil and Gas Commission

Gary Looney is a graduate of Louisiana Tech University with a degree in Petroleum Engineering Technology. Mr. Looney has worked both in the private sector of petroleum engineering and in state government oil and gas regulation for the past 31 years. While working for the Arkansas Oil and Gas Commission, he has held various positions and currently serves as Assistant Director in the El Dorado Regional Office with responsibilities for State Programs including Abandoned Well Plugging, Inspector Training and Safety, Field Operations, Permitting and Technical Services as well as Federal Programs including Underground Injection Control and Natural Gas Pipeline Safety. Mr. Looney is a Certified Safety and Health Official (CSHO), a member of the Society of Petroleum Engineers and holds multiple certificates in Underground Injection Control and from DOT/PHMSA in natural gas pipeline safety.

The Arkansas Oil and Gas Commission established an abandoned and orphan well plugging program by statute in 2005. Although the Commission had an informal process in-place prior to that time, the statue established a more formal program which included an ongoing funding mechanism. The Commission also established a formal regulatory process for declaring a well abandoned or orphaned and eligible for plugging utilizing program funds as well as creating an established plugging contractors selection procedure and project bidding process. The program currently has an appropriation of $2.5 million per year available for well plugging operations.

Abstract 44

High Volume Hydraulic Fracturing and Protection of Public Water Supply Sources

Joseph J. Lee, Jr., P.G., Ground Water Protection Council

Joe Lee received his Bachelor of Science degree in Geosciences from The Pennsylvania State University in 1977, and has completed course work for a Masters of Environmental Pollution Control. He has certificates in Hydrogeology and Geographic Information Systems. He has had over 35 years of experience, and is a subject expert in applying geologic and hydrogeological principles, and techniques in assessing environmental and public safety impacts of mineral resource development and other activities on groundwater, surface water, and water supply. He has developed and managed environmental protection programs for safe drinking water, groundwater and mineral resource development, including oil and gas. Mr. Lee served on the Board of Directors of the Ground Water Protection Council (GWPC) for over 10 years and has served as Treasurer, Vice-President, and President of the Board. Mr. Lee is a licensed professional geologist in the Commonwealth of Pennsylvania. He is the principle of Lee Geologic and serves on the GWPC staff.

Unconventional oil and gas development has, in just over a decade, developed into a significant contributor to oil and gas production in the United States, Canada, and other areas of the world where it has been successfully applied. Unconventional oil and gas development is dependent upon recent technical advancements that allows for exploitation of the reserves remaining in tight formations; and, principally, in the source rock of hydrocarbon generation. The oil and gas development of these tight formations requires directional drilling to allow maximum exposure of the source formation, and an increase in the source rock permeability through high volume hydraulic fracturing. Although the techniques for development of oil and gas from tight formations is new, the potential impacts on public water supply sources from oil and gas development are not. Recent research and reports have concluded that intrinsic and regional impacts to water quality has not occurred and is not likely to occur by regulated and properly operated unconventional oil and gas development activities in the United States. But, the scale of the operations in concentrated areas from unconventional oil and gas development, and water resource needs presents new considerations for public water supply protection. In some parts of the country, increased oil and gas development from unconventional formations has brought renewed opportunities for public water supply protection. Commonly used techniques in local, public water supply protection include increased water resource planning, monitoring, early warning, situational awareness, cooperation, and local education.

Abstract 45

Water Use for High Volume Hydraulic Fracturing in Oklahoma

Robert W. Puls, Robert Puls Environmental Consulting, LLC

Oklahoma has experienced an unprecedented increase in oil and gas extraction over the last five to ten years. With the advent of hydraulic fracturing in concert with the use of horizontal wells there has also been a dramatic increase in water usage. During this same time period, the state experienced an exceptional drought in 2011, 2012, and early 2013. Prior to this time, the state had experienced a relatively wet period. Current water demand projections contained in the 2012 state Water Plan may need to be reevaluated. Water usage trends in the oil and gas sector show that the fraction of total water demand for oil and gas in 2060 could exceed the projected 5% on a statewide basis and impacts may be significantly greater at the county or local scale. With a drop off of oil and gas extraction activity in 2014 and early 2015, water usage similarly was greatly reduced. State agencies and industry should work together as they have done in the past to explore ways to reduce fresh water demands when oil and gas extraction activity resumes its upward trend in the future.

Abstract 46

Nutrients in Groundwater, and Public Water Supply Protection

Joseph J. Lee, Jr., P.G., Ground Water Protection Council

Joe Lee received his Bachelor of Science degree in Geosciences from The Pennsylvania State University in 1977, and has completed course work for a Masters of Environmental Pollution Control. He has certificates in Hydrogeology and Geographic Information Systems. He has had over 35 years of experience, and is a subject expert in applying geologic and hydrogeological principles, and techniques in assessing environmental and public safety impacts of mineral resource development and other activities on groundwater, surface water, and water supply. He has developed and managed environmental protection programs for safe drinking water, groundwater and mineral resource development, including oil and gas. Mr. Lee served on the Board of Directors of the Ground Water Protection Council (GWPC) for over 10 years and has served as Treasurer, Vice-President, and President of the Board. Mr. Lee is a licensed professional geologist in the Commonwealth of Pennsylvania. He is the principle of Lee Geologic and serves on the GWPC staff.

High nutrients concentrations, and specifically Nitrates, in groundwater is one of the most common causes of source water quality based, maximum contaminant level violations of public water supply in the country. Furthermore, nitrate is listed by the US EPA as an “Acute” contaminant meaning the health risks associated with exposure to a contaminant occur within a short time period. There is also research suggesting chronic health effects from long term exposure to high nitrates. In addition to direct health effects, nutrients in groundwater can contribute to surface water eutrophication, and associated, adverse surface water quality conditions. Of particular concern for surface water eutrophication is low dissolved oxygen and harmful algal blooms. A basic concern for public water systems in areas of high nutrient concentrations is the ineffectiveness of standard water supply treatment. As such, control of nutrient contaminant sources in well recharge areas is an important consideration to avoid potential health effects and high treatment costs. The USGS has studied the increase of nutrients in ground water and surface water, and has identified probable areas, and causes for high nutrients in groundwater on a regional basis. In addition, other USGS studies have identified deep ground water flow systems may be a source of high nutrients in surface water for decades to come. Recent success in remediation of stream segments previously identified as impaired under the Clean Water Act for nutrients and success in decreasing high nutrient groundwater in some public water supply wells by addressing nutrient sources in the wellhead protection areas show approaches to protect ground water, and sources of public water supply.

Abstract 47

Kansas Oil and Gas Commission Abandoned and Orphan Well Plugging Program

Patrick Shields, Kansas Corporation Commission

Patrick R Shields, MBA is the Abandoned Well Plugging Supervisor for the Wichita based Conservation Division of the Kansas Corporation Commission. He earned his B.S. from Kansas State University in 2010 and most recently graduated from Wichita State University in 2015 with his MBA. Patrick began working for the KCC as a Petroleum Industry Regulatory Technician in 2011 and fully transitioned to his current position in August of 2014. Along with overseeing daily operations, Patrick is responsible for continuing to streamline the research and contract procurement processes as well as developing effective cost structure formulas for increasing the efficiency of contractor operations.

Kansas legislative action during the 1996 session resulted in the creation of the Abandoned Well Plugging and Site Remediation Fund, providing funding for the plugging of abandoned wells drilled prior to 1996 and the remediation of contamination sites. The Conservation Division of the Kansas Corporation Commission regulates oil and gas activities within the state and, by statute, the Commission has jurisdiction over all oil and gas contamination. Funding is composed of contributions from the State Water Plan, Conservation Fee Fund, and the Federal Mineral Leasing Program. Additionally, the Well Plugging Assurance Fund, which is financed by industry operators, was established to plug abandoned wells that were drilled post-1996.

The multifaceted process of plugging abandoned wells in Kansas involves locating, recording, and researching wells to determine if a potentially responsible party can be held liable for the plugging or care of the wells. If no such party can be identified, the wells are recorded in the Abandoned Well Database and prioritized based on their level of environmental threat to groundwater, surface waters, or public safety. Estimated low-cost projects are plugged by one of several contractors that have been awarded a 3-year Negotiated Bid contract. Projects with high cost estimations (>$30,000) are scheduled through the Kansas Department of Administration's Procurement and Contracts Division. Once proposals are received and reviewed, a contract is awarded in the best interests of the State of Kansas. Through June 30, 2015 the program has plugged 9,454 abandoned wells with 3,002 records still "Requiring Action".

Abstract 48

Kentucky Oil and Gas Commission Abandoned and Orphan Well Plugging Program

Kim Collings, Kentucky Division of Oil & Gas

The Kentucky Division of Oil and Gas estimates there are approximately 12,000 orphaned wells across the Commonwealth. The division's Oil and Gas Well Plugging Fund was created in order to help alleviate this problem. This program is funded through bond forfeitures that occur when operators do not correct violations in the given time frame. Recommendations for plugging come from division field staff who notify the central office when an orphaned well meets the criteria. Wells are selected each year for the plugging program on a priority scale based on environmental and safety concerns. The well condition and well location are factored into the selection process. Plugging contractors are selected through a bidding process. Once awarded, contractors have 120 days to complete the work with the guidance of field staff. The division also has a process for plugging wells on an emergency basis.

In addition to the plugging fund, the Division established a Well Testing Program that allows operators to temporarily test an orphaned well for viability. If the well meets the criteria for testing, operators are given 60 days to test the well after which they may select to place this well under their bond. Since the program's inception, 600 wells have been removed from the orphaned well list and placed back in production.

Kim Collings has served as the director of the Kentucky Division of Oil and Gas for seven years. Prior to becoming director, she served as a geologist and permit reviewer for the division over the past twenty years. Kim received her Bachelor of Science degree in Geology from Old Dominion University in Norfolk, VA and a Master of Science degree in Geology from Eastern Kentucky University in Richmond, KY.

Abstract 49

Oil & Gas Environmental Information

Paul Jehn, GWPC

The Ground Water Protection Council (GWPC), with support from the U.S. Department of Energy, has assisted regulatory agencies in oil and gas producing States for over 20 years to build the Risk Based Data Management System (RBDMS). The RBDMS software is the backbone of data systems in over 25 States and provides a convenient way for States to track oil and gas well histories including ownership, location, permitting, construction, and production. RBDMS is an innovative tool that has continually been improved and expanded to support the interest of States to run efficient and effective regulatory programs. RBDMS also has a core data system architecture that can be customized to meet the needs of individual States.

Building on this collaboration, the GWPC is developing the National Oil and Gas Gateway. The Gateway will be the first public website where select well level data from all participating States can be viewed, aggregated and retrieved from one location. Prior to the development of the Gateway, the only way to see a national picture of well level activity was to visit each producing State's website and consolidate the data or to purchase commercial databases. With the Gateway, data will be available via one website.

The Gateway is a collaborative initiative involving the GWPC, States, and the U.S. Department of Energy's Energy Information Administration (EIA) and Office of Fossil Energy. EIA is contributing the infrastructure to host the Gateway website, and sharing its expertise to map well information across the States in a logical, intuitive layout. Funding from the Office of Fossil Energy through the National Energy Technology Laboratory supports information exchange among State data managers, and the development and beta testing of new RBDMS modules and system enhancements.

RBDMS Environmental manages analytical laboratory and field sampling and results data for all environmental matrices. It includes secure logon, electronic data deliverable formats, a full reporting module with multiple export options, and a sophisticated user notification service. The WY DEQ will use RBDMS Environmental to merge analytical sampling and results data from three other major databases (storage tank program, UIC program, and USGS NWIS data) on a regularly scheduled basis for review. RBDMS Environmental is being used to accept submittals of pre-drill baseline water sampling results in Colorado. The Wyoming oil and gas agency also will use RBDMS Environmental for managing pre-drill sampling data.

Abstract 50

Municipal Wastewater Reuse in Oklahoma

Robert W. Puls, Robert Puls Environmental Consulting, LLC

The Oklahoma Water Survey together with faculty at the University of Oklahoma as well as staff with the Oklahoma Water Resources Board, Oklahoma Department of Environmental Quality, City of Norman, Tetra Tech and Garver sponsored three forums on April 23, May 14 and June 18, 2015. The forums were held at the National Weather Center in Norman.

The forums presented information on wastewater recycling, reclamation, and reuse as an option for many communities to augment their drinking water supplies, especially in areas where fresh water resources are limited. Such approaches could also help achieve the goal set out under Oklahoma's "Water Act for 2060" - to use no more fresh water in 2060 than was used in 2010 while preserving Oklahoma's population growth and economic development goals.

This talk will summarize these forums including information on water quality and water quantity management practices in Oklahoma, the current regulatory environment for reuse of water resources, technologies that can treat wastewaters to achieve water quality criteria and case studies from Texas where communities have adopted wastewater reuse to augment drinking water supplies.

Marcellus Shale Coalition, Dissolved Methane Method Study

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Rock J. Vitale, CEAC Co-Author Bio: Rock Vitale is a founding principal and technical director of chemistry at Environmental Standards, Inc., a private quality assurance consulting firm headquartered in Valley Forge, Pennsylvania. Rock has more than 30 years' experience in analytical chemistry quality assurance, working closely with oil and gas exploration and production companies to ensure the defensibility of their environmental data. Mr. Vitale is a recognized expert in organic and inorganic data validation; laboratory auditing; third-party review of quality assurance project plans; design of specialty analyses to accommodate project-specific data quality objectives; quality assurance oversight of complex projects; and agency negotiations.

Debby Yost Co-Author Bio: Debby L. Yost serves as a Senior Environmental Specialist with Chesapeake Energy Corporation and works at Chesapeake's corporate headquarters in Oklahoma City. Debby has been part of the Environmental Health and Safety and Regulatory Affairs Department since 2007. Debby has worked on a variety of projects involving both regulatory affairs and compliance issues associated with oil and gas exploration and production. Ms. Yost has also been an active participant in the Marcellus Shale Coalition and has been part of the Environmental Stewardship Subcommittee since 2010.

The practice of unconventional hydraulic fracturing for natural gas in the Appalachian Marcellus Shale formation has received intense media, political, and regulatory agency attention. The quality and defensibility of domestic groundwater well data is critical for the protection of human health and the environment and in determining the regulatory compliance as it relates to oil and gas exploration and production activities.

In reviewing years of dissolved methane concentrations generated by accredited laboratories, member companies of the Marcellus Shale Coalition (MSC) have been concerned with the disparity reported between laboratories during split sampling events. Because of this concern, the MSC commissioned a study to better understand the source(s) of the disparate dissolved methane concentrations. Environmental Standards, Inc., a quality oversight consulting company, was selected to conduct a round robin laboratory study. In November 2014, samples were collected from two domestic water wells and were submitted to 15 laboratories for the analysis of dissolved methane.

There are several published analytical procedures for the analysis of dissolved light gases in the aqueous medium, but there is not a published method at the federal level. Accordingly, any laboratory performing dissolved light gas analysis must develop their own analytical procedures resulting in potentially significant variation among laboratories. The study included collection of detailed information from each participating laboratory regarding their procedures for sample storage and handling, sample preparation, analysis, and calculation of concentration, thereby potentially identifying critical laboratory variables that influence the quantitation of dissolved methane in groundwater.

Disparate dissolved methane results were reported, validating the MSC's observations and concerns. An overview of the study design and the findings, including recommendations, will be presented.

Abstract 52

Water Cycle and Oil & Natural Gas Production

Thom Kerr, Thom Kerr, LLC

Water has been an element in the drilling and production life cycle of oil and gas wells since the early days of the industry. It is used during drilling, completion, and as a fluid driver in the later stages; it is produced along with the resource as a waste product. Fresh water is owned by individuals or corporations and controlled by state government oil and gas operators have long used fresh water for their drilling and completion operations. Waste water from oil and gas operations is regulated by state government and since the Clean Water Act this regulation has been under strict guidance of federal regulation.

Storage and transportation is a critical component of the management of both fresh and waste water and has evolved over time as the industry its regulatory and technological requirements have evolved. In today's environment with the development of new energy resources, unconventional resources, oil and gas wells are drilled at higher densities using larger volumes of water. Competition from population growth and higher industry demand on fresh water supplies, especially in areas suffering from drought conditions, is forcing new thinking to minimize the impacts from the increased completion for supply and water transportation on roads and around domiciles.

Part of all this new thinking is the merger of the fresh and waste water programs used by industry into a planned and managed package that minimizes volumes of fresh and waste water by creating a life cycle. In order to monitor this life cycle and new demands are placed on industry and government to track these water volumes as public concern has increased along with the increase in industry activity.

Thom Kerr works as an independent contractor with 25 years in regulatory and 13 years with independent oil and gas exploration companies. Thom retired from the Colorado Oil and Gas Conservation Commission at the end of 2013 after twenty-three years with the Commission. His desire is to stay active in retirement by mixing contract work, travel, gardening, and playing outdoors.

Abstract 53

Assessing Nutrients in Principal Aquifers of the United States – An Overview

Sandra M. Eberts

Sandra Eberts is a professional hydrogeologist who has been with the U.S. Geological Survey for 30 years. She coordinates the USGS National Water-Quality Assessment program Groundwater Modeling & Mapping team and serves as the USGS representative to the Source Water Collaborative. Her background includes water quality and quantity assessments ranging from the plume-scale to the principal aquifer-scale. Her current research interests include providing a flow-system context for groundwater-quality data. Eberts holds B.S. and M.S. degrees in geology from The Ohio State University and a certificate in legislative studies from Georgetown University.

Over the past two decades, the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) program has sampled about 6,600 wells to document where groundwater contaminants occur and to develop an understanding of the natural and human factors that affect contaminant occurrence in principal aquifers of the United States. Decadal-scale changes in groundwater quality were evaluated on the basis of paired samples from 67 well networks containing 1,498 wells. Nitrate concentrations increased significantly in 25 percent of these sampling networks. Results will be made available through a new web tool.

Over the next decade, NAWQA will resample about 2,500 shallow to intermediate-depth wells to further understand water-quality changes beneath urban and agricultural lands and in deeper domestic wells. The relation between long-term changes and short-term water-quality variability is being investigated by sampling at a higher frequency in a nest of wells in 8 of the principal aquifers. Nitrate sampling in these
8 trends networks will take place bi-monthly for 3 years and annually for 6 years. Environmental tracers of groundwater age are being used to help evaluate the timescales for water-quality change.

Untreated water from 80 to 120 public-supply wells in each of 20 principal aquifers also is being sampled by the NAWQA program for the first time. The public-supply wells are spatially distributed across entire principal aquifers, rather than targeted smaller areas. This sampling design will

enable the proportion of each aquifer having elevated concentrations of nutrients to be estimated. Because water-quality observations by themselves provide a spatially limited understanding of groundwater quality, statistical models are being used to extrapolate between sampling locations and to create spatially continuous maps of nutrient concentrations in groundwater at the national scale and in greater detail in the Central Valley, Glacial, Northern Atlantic Coastal Plain, and Mississippi-Embayment principal aquifers.

Abstract 54

Making Use of Groundwater as Part of an Alternative Water Supply Strategy for Adaptation to Climate Change

Jamie Crawford, PG, the Pickering Firm

Meeting increasing demands for water is a constant challenge at all levels of government, and pressure to find both short-term and long-term water supply solutions has never been as urgent in many regions of the country as it is today. States, tribes, municipalities, industry, and water supply entities are engaged in water resource planning to meet current and future challenges posed by climate extremes (both the short and long term), increasing pressures on existing resources from population growth, competition for resources among various industries, and quantity and quality issues associated with current supplies. To facilitate the use of alternative water resources as part of an overall supply strategy, the Ground Water Protection Council is releasing a new chapter in its Ground Water Report to the Nation series titled, *Groundwater & Alternative Water Supplies.* This talk will review key elements of the new chapter that will provide basic information for adaptation to climate change.

Water conservation and repairs to leaky infrastructure are usually the first steps taken to help stretch existing resources; however, the hunt is on to identify new water sources to meet increasing demands. Alternative water resources can be an important part of an informed adaptation decision strategy. Untapped or underutilized groundwater sources may be available locally to supplement or provide needed capacity to water systems. Switching to "undesirable" water for industrial and agriculture purposes, brackish groundwater desalination, stormwater harvesting, aquifer storage and recovery, and water reuse are five groundwater-related resources that are either currently used or being considered for development in many areas of the nation.
As water supplies become less reliable, all levels of government will need to evaluate the potential to use alternative water resources and if the management of alternative groundwater resources can help meet future demands. Federal, state, tribal, and municipal governments will need to encourage and facilitate the use of alternative water resources and help users to overcome the perception that these resources are “wastes." One of the key challenges to using alternative resources is getting local-level acceptance that these are viable, long-term water supplies that justify the expense associated with investigation and characterization, as well as development of the infrastructure needed to utilize them.

Jamie presently is employed as the Water Resources Program Manager at the Pickering Firm in Jackson, Mississippi. He recently retired from the Mississippi DEQ where he served as the Director of the Office of Land and Water Resources. During his career with MDEQ, Jamie administered the Source Water Assessment/Protection program and the Underground Injection Control program, but his primary responsibility focused on the development and implementation of management approaches to ensure the effective utilization and protection of state water resources. Jamie holds B.S. and M.S. degrees in geology and is a past President of GWPC.

Abstract 55

A National Program for Outreach & Education to Private Well Owners

Steve Wilson[1], Jennifer Wilson
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Through funding from the USEPA and in collaboration with the Rural Community Assistance Partnership (RCAP), a national program has been developed to conduct outreach, technical assistance, and education to private well owners. The program started with the development of The Private Well Class, an online course for well owners, and has now been expanded to include direct technical assistance and education through partners including the National Ground Water Association, the Water Systems Council, the National Environmental Health Association, and the RCAP regional and state offices throughout the 50 states and US territories. In this presentation, we will describe the program, the planned effort over the next 14+ months, and the goals of the project through 2016. The project includes workshops for sanitarians, providing direct assistance to well owners throughout the country, leveraging existing private well experts as partners, and putting in place a program that can be shared nationally, as well as locally, to provide stakeholders working with private well owners tools that will help them both reach more people and generate more well owner interest in sampling and becoming better managers of their wells and water supply.

Abstract 56

Investigating Injection-Induced Seismicity through Reservoir Modeling and Simulation of the Arbuckle Saline Aquifer, South-Central Kansas

Tandis S. Bidgoli, Mina FazelAlavi, and Yevhen Holubnyak, Kansas Geological Survey

Tandis Bidgoli is an Assistant Scientist with the Energy Research Section of the Kansas Geological Survey (KGS) and a Courtesy Assistant Professor in the Department of Geology at the University of Kansas. She earned a M.S. from the University of Nevada and a Ph.D from the University of Kansas. Prior to joining the KGS, she contributed to a number of industry projects as an Exploration Geologist for ExxonMobil. She is a structural geologist and low-temperature thermochronologist that focuses on the evaluation of subsurface geologic systems for energy exploration and development.

The Cambro-Ordovician Arbuckle Group is one of the principle reservoirs used for UIC Class I and II injection in the central U.S. A number of factors have contributed to its predominance as a disposal interval, including its depth and confinement from underground sources of drinking water; thickness (up to ~400 m); high permeability (10-1500 mD); and low pressure (below hydrostatic). However, recent seismicity in Kansas may be challenging assumptions about the Arbuckle being an ideal disposal zone, particularly for large volume injection. From 2013-2015, more than 200 earthquakes occurred in a two-county area in the south-central part of the state. The seismicity is temporally and spatially coincident with major brine disposal operations, raising concerns about the safety and efficacy of underground fluid injection. To evaluate these issues and potential mitigating strategies, we constructed a geologic model of the Arbuckle in Petrel™. The model incorporates reservoir property data from ~18 wells and dynamic data from 103 saltwater disposal wells, covering a 5500 km² area. Well data were analyzed using a wide range of techniques in order to determine porosities, horizontal and vertical permeabilities, water saturations, and flow units within the Arbuckle. The resulting 20 layer geologic model was simulated in CMG™ and shows an increase in reservoir pressure across the model area after 26 years of injection. The largest change in reservoir pressure occurs near the highest rate injection wells; however, the simulations also show that there is a broader cumulative pressure response across the model area. Although the change in pressure near the Arbuckle-basement interface is not large (10-70 psi), hydraulic connections via critically-stressed basement faults could transmit fluid pressure deeper and trigger seismicity.

Abstract 57

Water Quality Treatment Considerations for Non-Hazardous Disposal Wells Injecting Under Pressure

Nicole Franken, E.I.T. and Chad Milligan, P.G., SCS Aquaterra

Diminishing capacity of non-hazardous disposal wells injecting under pressure may be related to the water quality and treatment of injectate fluid. For one coal mine in southern Illinois, native groundwater infiltrating the mine is treated using five main components: coagulation and sedimentation, green sand filtration, reverse osmosis, chemical injection of biocide and anti-scalant, and disposal. The injection well primarily functions to dispose the concentrate generated from the reverse osmosis treatment system.

The treatment and disposal of native groundwater infiltrating the mine was analyzed using a holistic approach, including an evaluation of the water quality by assessing the chemical and physical characteristics of water, water quantities, water treatment system, geochemistry, and applicable disposal well characteristics. The analysis identified specific minerals that may be precipitating from the concentrate and causing scaling issues within the disposal well, the specific location within the disposal well the scale could be forming, and recommendations to address the scaling issue both through a well stimulation plan and adjustments to the groundwater treatment system design and operation.

Understanding how scale forms can help formulate a plan for treating the well. Temperature and pressure fluctuations can have an impact on solubility coefficients, and can also cause local fluctuations in the equilibrium ion concentration in the solution. Once the seed crystals start growing, the heterogeneous nucleation process may start at surface defects such as joints, seams, or areas with surface roughness. A high degree of turbulence can also start the process of scale deposition, such as restrictions in the well. This presentation will focus on why and where scale forms in a groundwater treatment and disposal system and how to prevent it, which will assist to avoid costly workovers and inefficiencies in chemical dosing.

Nicole Franken is an Engineer in Training in the State of Kansas. She has a Bachelor of Science degree in Civil Engineering with an Environmental Emphasis from the University of Kansas. She has a broad range of experience in environmental engineering including regulatory compliance and permitting, remediation projects from initial site assessment through site closure, environmental liability cost modeling, wastewater treatment design, and hydraulic modeling. She has been involved with various aspects of UIC wells including the closure of a Class I UIC well in Texas and performing capacity reduction investigations.
Chad Milligan is a licensed professional geologist in the states of Kansas and Illinois. He has a Bachelor of Science degree in Environmental Chemistry from Emporia State University and a Master's Degree in Environmental Science from Wichita State University. He has over 20 years of experience in the environmental field and has been responsible for the permitting and regulatory compliance of Class I non-hazardous disposal wells in the States of Kansas and Illinois; the permitting of Class II disposal wells in Colorado; the permitting and regulatory compliance of Class III salt solution mining wells, and LPG storage caverns in Kansas; and the permitting and regulatory compliance of Class V UIC wells in Kansas. He also has a broad range of experience in water resources and has authored and co-authored a number of published reports relating to surface water and ground water quality in central Kansas.

Abstract 58

Geologic Feasibility of Class I Injection Wells in the Deep Portions of the Illinois Basin

Monte Markley, P.G. and Stephanie Hill, SCS Aquaterra

The Illinois Basin has an extensive history of surface coal mining dating back to the early 1800's. The Illinois Basin has experienced a resurgence of underground long wall operations with the migration of Appalachia-based coal mining operations over the last decade. This type of mining is conducted under hydraulic roof supports that advance as the coal seam is cut. As the supports advance, the roof collapses behind the cutting head, causing fractures to propagate through water-bearing sandstone formations and resulting in large volumes of fluid infiltrating into the underground workings. Up to 2 million gallons per day have been produced in the southern Illinois mines. The native groundwater contains naturally-occurring elevated chlorides that exceed surface water effluent limitations and are not permitted to discharge to Illinois surface waters. However, the fluid is permitted to be disposed of in Class I non-hazardous wells.

Because there is sparsely documented geophysical information available from deep boreholes in the southern part of the state, information from central and northern Illinois was extrapolated for purposes of evaluating the geologic suitability of selected injection intervals for fluid disposal in the deepest portions of the basin. Published data identified several formations as being aerially extensive and having good porosity development in the Ordovician and Cambrian systems. Exploratory boreholes were drilled for two underground coal operations into or near the Precambrian basement with total depths ranging from 12,000 to 13,000 feet. The wells were completed as partially perforated cased and open hole through the injection interval. Cores taken during initial drilling of the boreholes supported published data that the Ordovician formation displayed vugs that appeared to be interconnected. Laboratory tests revealed otherwise, showing an over-consolidated, low porosity and permeability formation lacking interconnectivity of voids due to secondary mineralization. Furthermore, the most suitable Cambrian-aged formation is thin or absent in the deeper basin. Post completion step-rate and pressure formation fall-off tests revealed that the uppermost formation in the injection interval preferentially accepted fluid under pressure. This presentation will explore the successes and lessons learned from completion and testing of these deep injection wells and examine future drilling and completion practices within the deeper portion of the Illinois Basin.

Monte Markley obtained a Bachelor of Science degree from Lamar University and is licensed as a professional geologist in Kansas and Missouri. He is vice president/senior project director with SCS Aquaterra and manages the Wichita operations within the firm.

Stephanie Hill obtained a Bachelor of Science degree from the University of Texas at Austin in geological sciences with a focus on hydrogeology. Ms. Hill is currently a project director with SCS Aquaterra and oversees the St. Louis area operations. Previously, she directed the Title V coal permitting and reclamation program at the Railroad Commission of Texas.

Abstract 59

Stakeholder Engagement and Development of Water Management Strategies

Andra Wilcox – Environmentally Friendly Drilling Systems (EFD) Program, managed by the Houston Advanced Research Center (HARC)

Andra Wilcox - Research Associate. Andra conducts on-site evaluations of drilling and completions operations in diverse ecosystems. She assists with the development of the EFD Scorecard and coordinates the development of the EFD Virtual Site, an interactive workforce development and stakeholder engagement tool.

Uncertainty about how environmental aspects are being addressed is often expressed by communities surrounding oil and gas development. Industry has made great strides in the protection of the environment, however challenges still exist. Concerns about industry's use of water, as well as the management of flowback and produced water from operations, have operators striving to develop effective water management strategies and how to better communicate such measures to the public.

The Environmentally Friendly Drilling Systems (EFD) Program provides unbiased science to identify and demonstrate technologies and practices designed to address environmental and societal aspects. The EFD Scorecard was created as a voluntary, consensus-based tool that measures how industry is addressing these

issues. It has been tested on various sites in different ecosystems across North America so that it serves as an adaptive ecosystem services management tool to assist operating companies in planning and implementing good practices, such as those found in effective water management strategies.

While the Scorecard includes six attributes (Air, Water, Site, Waste Management, Biodiversity/Habitat, and Societal) this paper will focus upon Water. Reviewing standard operating procedures such as setbacks from streams and sources and the mitigation measures in place to protect ground and surface waters, the Scorecard can be a tool for operators to help improve communication with all stakeholders and assist in ongoing relationships with regulators. The Scorecard provides the unbiased data in understandable and approachable terminology that has been vetted by industry, environmental groups, academia and NGO's. Communicating the measures taken by industry in terms relevant to all stakeholders is vital to earning not only a license to operate, but also, an invitation to operate.

The Scorecard can be used to objectively assess operators' environmental performance. Such a tool to measure and share the performance and commitment of operators can help allay unease about transparency. Benchmarking best management practices in action and making such data available can also provide the necessary improvement in communication with all stakeholders.

Abstract 60

The Oil & Natural Gas Industry Working to Enhance Water Management Technologies

Jill E. Cooper, Anadarko Petroleum Corporation

The Energy Water Initiative (EWI) is a collaborative effort (not a trade organization) among participating members of the U.S. oil and natural gas industry to study, describe, and improve lifecycle water use and management in upstream unconventional oil and natural gas exploration and production. The companies participating in EWI collectively recognize the importance of water management and conservation, and the role technology and knowledge-sharing can play in continuous improvement. EWI seeks to gather and develop recommended management practices and technologies that industry can employ to efficiently use and conserve water resources. In 2014 and 2015, 12 of the EWI Participants conducted a case studies project and issued a publicly available report. This presentation will share the key findings of that report. In addition, Anadarko recognizes that effective water management and water conservation are essential to developing all energy resources for our world. We have established an internal Strategic Water Committee to define and implement a holistic water-management approach for Anadarko that assesses availability and prudent use of water, conservation technology development and public outreach to address water management and challenges according to local conditions and considerations. An example of Anadarko's actions, we implemented a water recycling and closed-loop system Water-On-Demand (WOD), consisting of more than 150 miles of pipeline in Colorado. We will provide more information about this effective and important WOD system and the benefits to the community, environment and Anadarko.

Jill Cooper is a Corporate HSE Manager Reporting & Advocacy for Anadarko Petroleum Corporation and works on global air quality, water resources, air quality, and other environmental matters for the company. She received her MBA in International Business at Thunderbird School of Global Management and her JD in Environmental Law at the University of Colorado Law School (1996). She held several positions at the Colorado Department of Public Health & Environment, practiced law at Faegre & Benson LLP, and was a lead of environmental programs at another oil and natural gas company.

Abstract 61

Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources in the United States

Jeff Frithsen – USEPA Office of Research and Development

The U.S. Environmental Protection Agency recently released a draft assessment of the potential impacts of hydraulic fracturing for oil and gas on drinking water resources. Based upon review of over 950 sources of data and information, EPA concluded that there are above and below ground mechanisms by which hydraulic fracturing activities have the potential to impact drinking water resources. These mechanisms include: water withdrawals in times of, or in areas with, low water availability; spills of hydraulic fracturing fluids and produced water; fracturing directly into underground drinking water resources; below ground migration of liquids and gases; and inadequate treatment and discharge of wastewater. EPA found specific instances where one or more mechanisms led to impacts on drinking water resources, including contamination of drinking water wells. The number of identified cases, however, was small compared to the number of hydraulically fractured wells, and there was no evidence of widespread, systemic impacts on drinking water resources due to hydraulic fracturing activities. This finding could reflect a rarity of effects on drinking water resources, but may also be due to other limiting factors. These factors include: insufficient pre- and post-fracturing data on the quality of drinking water resources; the paucity of long-term systematic studies; the presence of other sources of contamination precluding a definitive link between hydraulic fracturing activities and an impact; and the inaccessibility of some information on hydraulic fracturing activities and potential impacts. EPA's assessment represents a synthesis of the science and contributes to overall understanding of potential impacts of hydraulic fracturing. The assessment can inform future decisions by industry and by federal, tribal, state and local entities concerning how best to protect drinking water resources now and in the future.

Jeff Frithsen is a senior scientist and special projects coordinator in USEPA's Office of Research and Development. His work has focused on developing agency scientific assessments that inform environmental management and policy decisions, including: an assessment of mountaintop mining and valley fill practices; a report to Congress on the environmental consequences of the increased use of biofuels; and a recent assessment of potential impacts of proposed large-scale mining in Bristol Bay, Alaska. He is currently coordinating the development of the agency's oil and gas hydraulic fracturing drinking water assessment report. He holds a B.S. in Biology from Boston College and a Ph.D. in Oceanography from the University of Rhode Island.